SIEMENS

SIMATIC

**PROFINET
System Description**

System Manual

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

CAUTION
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

NOTICE
indicates that an unintended result or situation can occur if the relevant information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

Preface

Purpose of the manual

The system description in hand conveys an overview of the PROFINET communication system.

This system description will support you in the installation, commissioning and the ongoing operation of a PROFINET system.

It also explains, with reference to examples, how to program diagnostics for IO devices.

It is intended for programmers of user programs and persons involved in configuring, commissioning and servicing automation systems.

Basic knowledge required

The following knowledge is required in order to understand the manual:

- General knowledge of automation technology

- You will also need to know how to use computers or PC-like equipment (such as programming devices) under the Windows operating system.

- Knowledge of STEP 7. You can acquire this knowledge in the Programming with STEP 7 (http://support.automation.siemens.com/WW/view/en/18652056) manual.

- Sound knowledge of PROFINET IO and PROFIBUS DP communication functions.

- Good knowledge of the SIMATIC distributed IOs

Scope

This documentation is the basic documentation for all products from the PROFINET environment. The documentation of the individual PROFINET products is based on this documentation.

Where this documentation fits in

In addition to this manual you require the following manuals depending on the application case.

- The PROFINET IO Getting Started: Collection (http://support.automation.siemens.com/WW/view/en/19290251) manual

- The Programming with STEP 7 (http://support.automation.siemens.com/WW/view/en/18652056) manual

- The From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) manual

Guide

The manual is structured into the following subject areas:

- Overview of PROFINET
- Structure and network components of PROFINET
- Transmission methods in PROFINET IO
- Engineering and Diagnostics in PROFINET IO
- Engineering and Diagnostics in PROFINET CBA

Important terms are explained in the glossary. The index helps you to quickly find all text passages relevant to your keyword.

Recycling and Disposal

On account of their low-emission equipment, the devices described in this document are recyclable. For environment-friendly recycling and disposal of your old equipment, contact a certified disposal facility for electronic scrap.

Changes compared to the previous version

The following table lists the most important new technological developments in PROFINET which have been taken into consideration in this system description.

New functions	Explanation
Media redundancy with MRPD	Ensuring network and system availability when a transmission link fails in connection with IRT
System redundancy	PROFINET IO devices can be connected system redundant to fault-tolerant CPUs.

Additional support

If you have questions about the products described here and do not find the answers in this manual, please refer to the contact at your local Siemens office.

- You will find information on who to contact at Internet (http://www.siemens.com/automation/partner).
- A guide to the technical documentation for the various SIMATIC products and systems is available at Internet (http://www.siemens.com/simatic-doku).
- The online catalog and online ordering systems are available at Internet (http://mall.automation.siemens.com).

Training Centers

We offer various courses for newcomers to the SIMATIC S7 automation system. Contact your regional training center or the central training center in 90327 Nuremberg, Germany.

You will find more information in the Internet (http://www.sitrain.com).

Technical Support

To contact Technical Support for all Industry Automation products, use the Support Request Web form (http://www.siemens.com/automation/support-request).

For additional information about Siemens Technical Support, refer to Internet (http://www.siemens.com/automation/service&support).

Service & Support on the Internet

In addition to our documentation, we offer a comprehensive knowledge base on the Internet (http://www.siemens.com/automation/service&support).

Here you will find the following information:

- The newsletter that provides you with latest information relating to your product
- The right documents for you, using our Service & Support search engine
- A bulletin board in which users and specialists worldwide exchange their know-how
- Your local contact partner for Industry Automation products in our Contact Partners database
- Information about on-site service, repairs, spare parts, and much more is available under "Repairs, spare parts, and consulting".

Table of contents

Guide to the PROFINET Documentation

<div style="text-align: right; font-size: 3em;">1</div>

Overview

The following documents contain information about the PROFINET topic.

Subject	Documents
PROFINET	System handbook PROFINET (current document)
	Programming Manual From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930)
Network components	Configuration Manual SIMATIC NET Industrial Ethernet Switches SCALANCE X-300 SCALANCE X-400 (http://support.automation.siemens.com/WW/view/en/19625108)
	Manual SIMATIC NET gateway IE/PB Link, (http://support.automation.siemens.com/WW/view/en/7851748) and Manual SIMATIC NET gateway IE/PB link PN IO for industrial Ethernet (http://support.automation.siemens.com/WW/view/en/19299692)
	Manual SIMATIC NET IE/AS INTERFACE LINK PN IO (http://support.automation.siemens.com/WW/view/en/22712154)
	Operating Instructions IWLAN/PB LINK PN IO (http://support.automation.siemens.com/WW/view/en/21379908)
Connection of PCs	Operating Instructions SIMATIC NET CP 1616/CP 1604 (http://support.automation.siemens.com/WW/view/en/26435795)
	Manual WinCC V6 Communication Manual (http://support.automation.siemens.com/WW/view/en/21320307)
	System Manual Industrial Communication with PG/PC Volume 1 - Basics (http://support.automation.siemens.com/WW/view/en/16923753) and Programming Manual Industrial Communication with PG/PC Volume 2 - Interfaces (http://support.automation.siemens.com/WW/view/en/24843817)

Subject	Documents
SIMATIC	Manual SIMATIC S7-300 CPU 31xC and CPU 31x: Technical data (http://support.automation.siemens.com/WW/view/en/12996906)
	Manual SIMATIC S7-400 Automation System S7-400 CPU Specifications (http://support.automation.siemens.com/WW/view/en/23904550)
	Operating Instructions Distributed peripheral system ET 200S (http://support.automation.siemens.com/WW/view/en/1144348)
	Operating Instructions Distributed I/O Device ET 200M (http://support.automation.siemens.com/WW/view/en/1142798)
	Operating Instructions ET 200pro distributed I/O system (http://support.automation.siemens.com/WW/view/en/21210852)
	Operating Instructions DET 200eco PN distributed I/O device (http://support.automation.siemens.com/WW/view/en/29999018)
	Operating Instructions Windows Automation Center RTX WinAC RTX 2009 (http://support.automation.siemens.com/WW/view/en/38016351)
	Device manuals CP 343-1 (http://support.automation.siemens.com/WW/view/en/24485272) CP 343-1 Lean (http://support.automation.siemens.com/WW/view/en/23643456) CP 343-1 Advanced (http://support.automation.siemens.com/WW/view/en/28017299) CP 443-1 (http://support.automation.siemens.com/WW/view/en/27013386) CP 443-1 Advanced (http://support.automation.siemens.com/WW/view/en/23643789)
Component Based Automation	Manual Create Component Based Automation PROFINET components (http://support.automation.siemens.com/WW/view/en/24858559)
	Configuration Manual Configure SIMATIC iMap plants (http://support.automation.siemens.com/WW/view/en/22762190)

Subject	Documents
STEP 7	Programming Manual Programming with STEP 7 V5.5 (http://support.automation.siemens.com/WW/view/en/18652056)
	Manual Configuring Hardware and Communication Connections STEP 7 V5.5 (http://support.automation.siemens.com/WW/view/en/18652631)
PROFINET compatibility list	Compatibility list (http://support.automation.siemens.com/WW/view/en/44383954)

SIMATIC Manuals

In the internet (http://www.siemens.com/automation/service&support) you will find the latest versions of all the SIMATIC manuals. These can be downloaded free of charge.

PROFINET overview

2

Content of this section

The main topics covered in this chapter are as follows:

- New technological developments from PROFINET
- Basics and basic terminology of PROFINET
- Connecting PROFIBUS to PROFINET
- Basics of PROFINET IO
- Basics for Component Based Automation
- Differences, common features and interaction of PROFINET IO and Component based Automation (PROFINET CBA)

Read this chapter to familiarize yourself with PROFINET.

Details on Differences and Common Features of PROFINET IO and PROFIBUS DP

For additional information, see the From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) programming manual.

2.1 Introduction

What is PROFINET IO?

Within the framework of Totally Integrated Automation (TIA), PROFINET IO is the consistent further development of:

- PROFIBUS DP, the established fieldbus and
- Industrial Ethernet

PROFINET IO is based on 20 years of experience with the successful PROFIBUS DP and combines the normal user operations with the simultaneous use of innovative concepts of the Ethernet technology. This ensures the smooth migration of PROFIBUS DP into the PROFINET world.

PROFINET IO as the Ethernet-based automation standard of PROFIBUS International defines a cross-vendor communication, automation, and engineering model.

With PROFINET IO a switching technology is implemented that allows all stations to access the network at any time. In this way, the network can be used much more efficiently through the simultaneous data transfer of several nodes. Simultaneous sending and receiving is enabled through the full-duplex operation of Switched Ethernet.

PROFINET IO is based on Switched Ethernet full-duplex operation and a bandwidth of 100 Mbps.

Application model

During the development of PROFINET IO, special emphasis was placed on the protection of investment for users and device manufacturers. The application model is retained for the migration to PROFINET IO.

Compared with PROFIBUS DP, the process data view remains unchanged for:

- I/O data (access to the I/O data via logical addresses)
- Data records (storage of parameters and data)
- Connection to a diagnostics system (reporting of diagnostic events, diagnostics buffer)

This means that the familiar view for access to the process data is used in the user program. Existing programming know-how can continue to be used. This also applies to device profiles, such as PROFIsafe, PROFIdrive etc. which are also available with PROFINET IO.

The engineering view also has a familiar "look and feel". The engineering of the distributed I/O is performed in the same way and with the same tools as already used for PROFIBUS.

Objectives in PROFINET

The objectives in PROFINET are:

- Open Ethernet Standard for automation based on Industrial Ethernet.
  Although Industrial Ethernet and Standard Ethernet components can be used together, the Industrial Ethernet devices are more sturdy and therefore better suited for industrial environments (temperature, immunity to interference, etc.)

- Use of TCP/IP and IT standards

- Automation of applications requiring real time.

- Total integration of field bus systems

Implementation of PROFINET in SIMATIC

PROFINET is implemented as follows using SIMATIC products:

- We have implemented communication between field devices in SIMATIC with **PROFINET IO**.

- In SIMATIC, communication between controllers as components in distributed systems is implemented with **PROFINET CBA** (Component Based Automation).

- Installation engineering and network components are available in SIMATIC NET.

- Established IT standards from the Office environment (e.g., SNMP=Simple Network Management Protocol for network parameter assignment and diagnosis) are used for remote maintenance and network diagnostics.

Documentation from PROFIBUS International on the Internet

You will find numerous documents about PROFINET on the PROFIBUS International Website (http://www.profibus.com).

Additional information can be found on the Internet (http://www.siemens.com/profinet).

Information on the migration from PROFIBUS DP to PROFINET IO can be found in the From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) manual.

2.2 Terminology in PROFINET and PROFIBUS

Definition: Devices in the PROFINET environment

In the PROFINET environment, "device" is the generic term for:

- Automation systems (PLC, PC, for example)
- Distributed I/O systems
- Field devices (for example, PLC, PC, hydraulic devices, pneumatic devices) and
- Active network components (e.g. switches, routers)
- Gateways to PROFIBUS, AS interface or other field bus systems

Definition: PROFINET devices

A PROFINET device always has a PROFINET interface (electrical, optical, wireless).
A lot of devices also have a PROFIBUS DP interface to connect PROFIBUS devices.

Definition: PROFIBUS devices

A PROFIBUS device has at least one PROFIBUS interface with an electrical (RS485)
or optical (polymer optical fiber, POF) interface.

Comparison of the terms used in PROFIBUS DP and PROFINET IO

The following graphic shows the general names used for the most important devices in PROFINET IO and PROFIBUS DP. This is followed by a table listing the names of the various components in the PROFINET IO and PROFIBUS DP contexts.
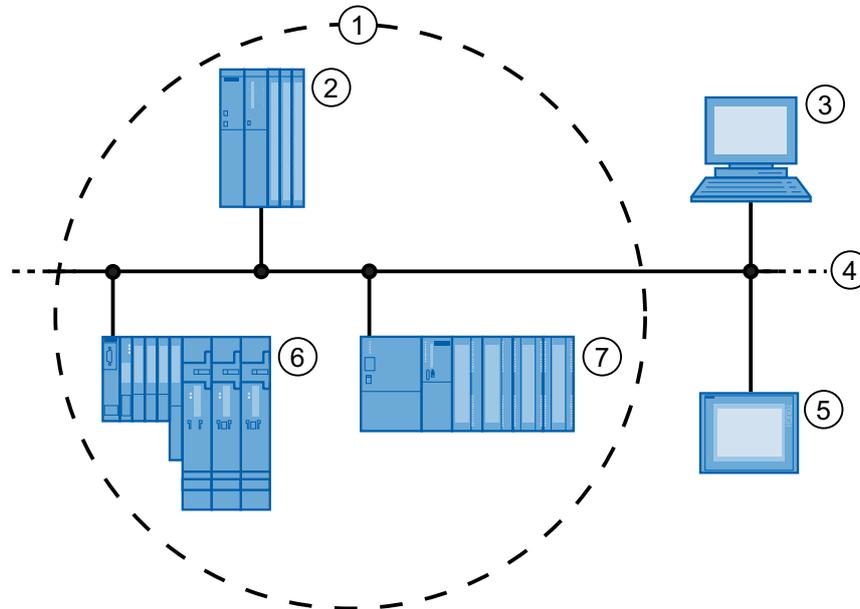
Number	PROFINET	PROFIBUS	Note
①	PROFINET IO system	DP master system	
②	IO controller	DP master	Device used to address the connected IO devices/DP slaves. This means that the IO controller/DP master exchanges input and output signals with field devices. The IO controller / DP master is often the controller on which the automation program runs.
③	Programming device / PC (PROFINET IO supervisor)	Programming device/PC Class 2 DP master	Programming device / PC / HMI device used for commissioning and diagnostics
④	PROFINET / Industrial Ethernet	PROFIBUS	Network infrastructure
⑤	HMI (Human Machine Interface)	HMI	Device for operating and monitoring functions.
⑥	IO device	DP slave	Distributed field device assigned to one of the IO controllers / DP masters, for example, distributed IO, valve terminal, frequency converter, and switches with integrated PROFINET IO functionality.
⑦	I-device	I slave	Intelligent IO device and intelligent DP-slave.

Figure 2-1   PROFINET and PROFIBUS devices

2.3 Structure of a PROFINET device

2.3.1 PROFINET interface with integrated switch

Overview

PROFINET devices from the SIMATIC family have a PROFINET interfaces (Ethernet-controller / interface) with one or multiple ports (physical connection possibilities).

For PROFINET devices with multiple ports (two or more), we are dealing with devices with an integrated switch.

Profinet devices with two ports are particularly ideal for the construction of networks in linear or ring topology. PROFINET devices with three and more ports are also ideal for setting up tree topologies.

Properties and rules for naming the PROFINET interface and its representation in STEP 7 are explained in the following.

Advantage

The PROFINET devices with integrated switch enable you to create a system with a linear or tree topology. A lot of current PROFINET devices also support the connection of ring structures.

Properties

Every PROFINET device on the network is uniquely identified via its PROFINET interface. For this purpose, each PROFINET interface has:

- A MAC address (factory default)
- An IP address
- A device name (NameOfStation).

Identification and numbering of the interfaces and ports

Interfaces and ports for all modules and devices in the PROFINET system are identified with the following characters:

Table 2- 1   Identification for interfaces and ports of PROFINET devices

Element	Symbol	Interface number
Interface	X	In ascending order starting from number 1
Port	P	In ascending order starting from number 1 (each interface)
Ring port	R	

Examples of identification

These two examples illustrate the rule for identifying PROFINET interfaces:

Table 2- 2   Examples for identifying PROFINET interfaces

Sample labeling	Interface number	Port number
X2 P1	2	1
X1 P2	1	2
X1 P1 R	1	1 (ring port)

Representation of the PROFINET interface in STEP 7

In STEP 7, the PROFINET interface for an IO controller and an IO device is represented as shown in the following diagram.
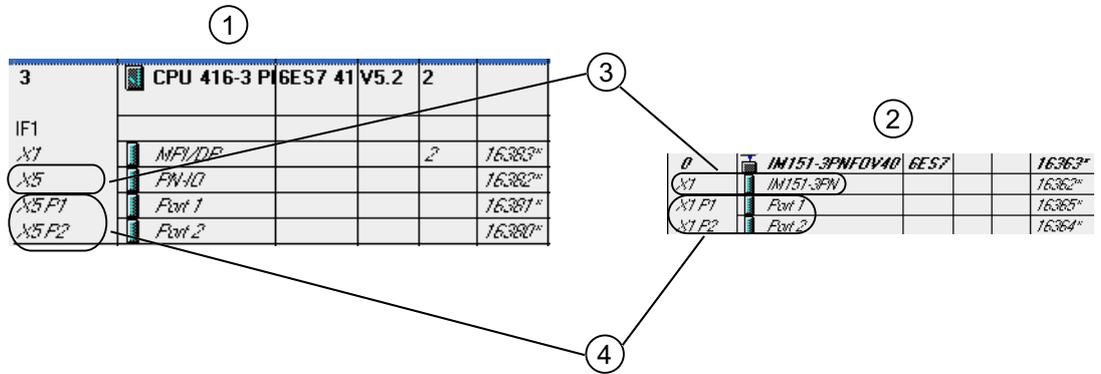
Numb er	Description
①	PROFINET interface of an IO controller in STEP 7
②	PROFINET interface of an IO device in STEP 7
③	This line represents the PROFINET interface (interface).
④	These lines represent the "port" of a PROFINET interface.

Figure 2-2   Representation of the PROFINET interface in STEP 7

Note

Logical addresses of the PROFINET IO interface

Both the interface and the ports are mapped onto submodules with separate diagnostics addresses - as with the device model for a PROFINET device.

Technical specifications

The following schematic diagram shows the PROFINET interface with the integrated switch and its ports for all PROFINET devices.
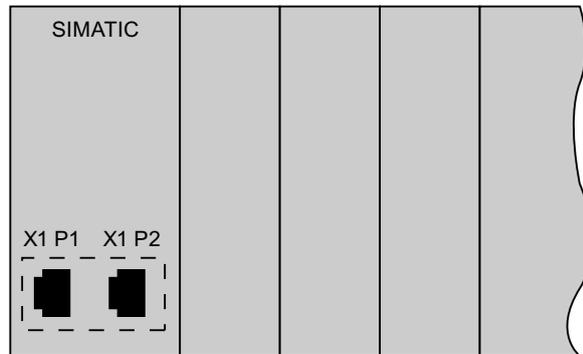
Figure 2-3   PROFINET interface with integrated switch

The table summarizes the technical specifications for a PROFINET interface with integrated switch or an external switch.

Table 2- 3   Technical Specifications of PROFINET Interface

Physical properties	Connection methods	Cable type / transmission medium standard	Transmission rate / mode	Max. segment length	Advantages
Electrical	RJ 45 cable connector ISO 60603-7	100Base-TX 2x2 twisted, symmetrical and shielded copper cable, CAT 5 transmission requirement IEEE 802.3	100 Mbps / full duplex	100 m	Simple and cheap power connection
Optical	SCRJ 45 ISO / IEC 61754-24	100Base-FX POF fiber-optic cable (Polymer Optical Fiber) 980/1000 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps / full duplex	50 m	Use when there are large differences in potential Insensitive towards electromagnetic radiation Low line attenuation Considerably longer segments possible
		Plastic-cladded glass fiber (Polymer Cladded Fiber, PCF) 200/230 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps / full duplex	100 m	
	BFOC (Bayonet Fiber Optic Connector) and SC (Subscriber Connector) ISO/IEC 60874	Monomode glass fiber optic cable 10/125 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps / full duplex	26 km	
		Monomode glass fiber optic cable 50/125 µm and 62.5/125 µm (core diameter / external diameter) ISO/IEC 9314-4	100 Mbps / full duplex	3000 m	
Radio waves	-	IEEE 802.11 x	Depending on the expansion used (a / g / h / etc.)	100 m	Greater mobility Cost-effective networking to remote, difficult to access nodes

More detailed information on passive network components

More detailed information can be found on the Service&Support pages on the Internet (http://www.siemens.com/automation/service&support).

More detailed information on diagnostics in PROFINET IO

For more detailed information, see the From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) programming manual.

More detailed information on communication with PROFINET IO

For more detailed information, see the Communication with SIMATIC (http://support.automation.siemens.com/WW/view/en/1254686) manual.

2.3.2 Modules of a PROFINET device

Slots and submodules

A PROFINET device can have a modular and compact structure. A modular PROFINET device consists of slots into which the modules/submodules are inserted. The modules / submodules have channels which are used to read and output process signals. A compact device has the same design, however, it cannot be physically expanded, this means that no modules/submodules can be inserted.

This is illustrated by the following graphic.
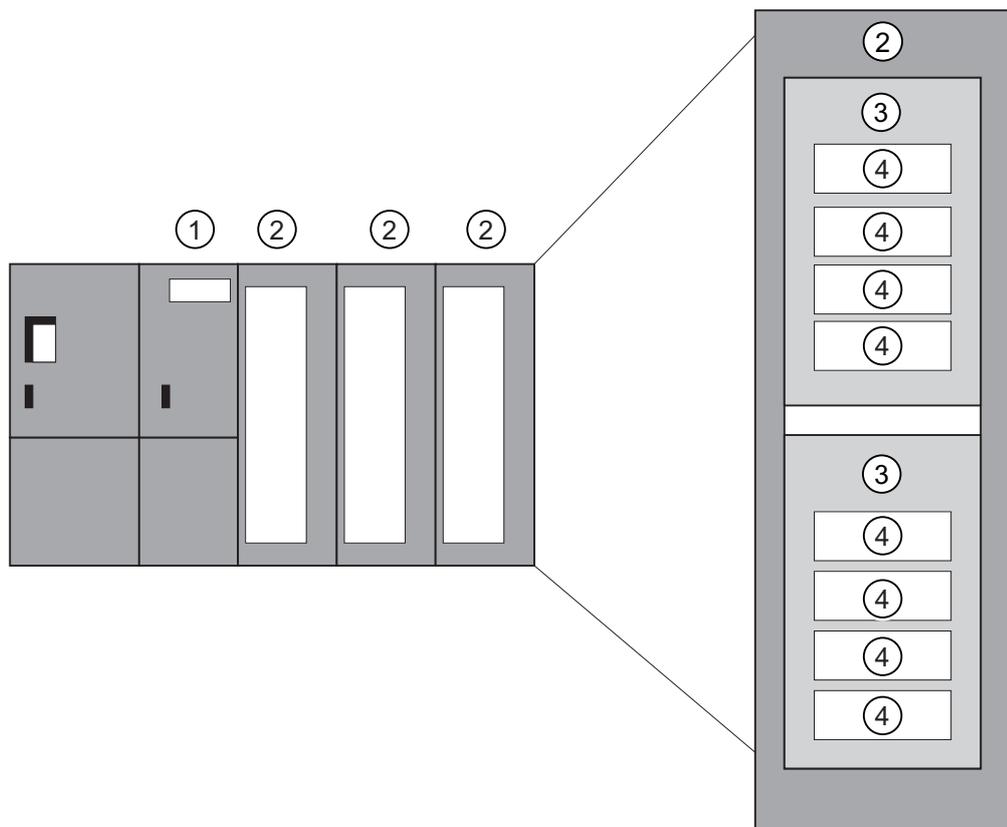
Figure 2-4   Structure of a PROFINET device

Number	Description
①	Slot with interface module
②	Slot with module
③	Subslot with submodule
④	Channel

A module can contain multiple submodules.

2.4 Integration of fieldbuses into PROFINET

Fieldbus integration

PROFINET allows you to use a proxy to integrate existing fieldbus systems (for example, PROFIBUS, ASI, etc.) into PROFINET. In this way, you can set up hybrid systems consisting of fieldbus and Ethernet-based subsystems. This enables a continuous technological transition to PROFINET.

Interconnecting PROFINET and PROFIBUS

If a PROFINET device additionally has a PROFIBUS interface (for example, CPU 319-3 PN/DP), then you can integrate existing PROFIBUS configurations into the PROFINET configuration through this interface.
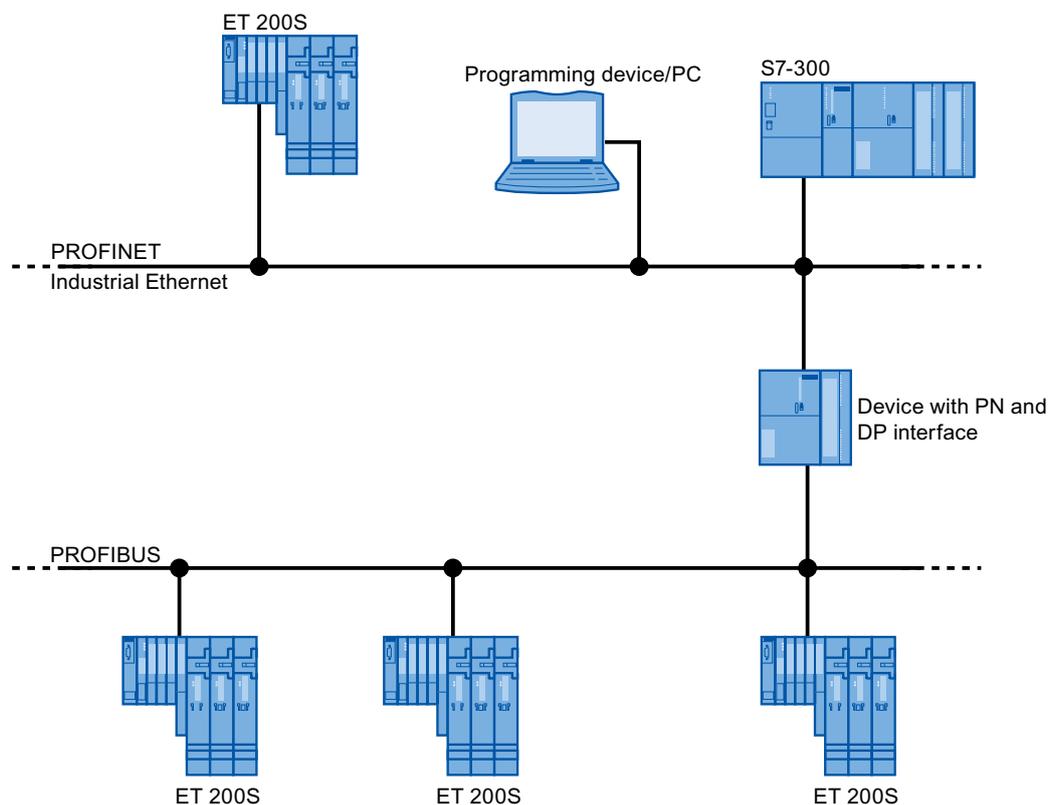

Figure 2-5   PROFINET devices, PROFIBUS devices, and proxy

Connection of PROFIBUS DP with PROFINET via Industrial Wireless LAN

You can connect PROFIBUS devices via a wireless LAN / PB link to PROFINET IO. This allows you to integrate existing PROFIBUS configurations in PROFINET.

Connection of AS-Interface to PROFINET

AS interface devices can be connected to the interface of a PROFINET device by means of an IE/AS-i link PN IO. This allows you to integrate existing AS-i networks in PROFINET.

PROFINET device with proxy functionality = substitute

The PROFINET device with proxy functionality is the substitute for a PROFIBUS device on Ethernet. The proxy functionality allows a PROFIBUS device to communicate not only with its master but also with all nodes on PROFINET.

With PROFINET, existing PROFIBUS systems can be integrated into the PROFINET communication with the aid of an IE/PB link, for example. The IE/PB link then handles communication via PROFINET on behalf of the PROFIBUS components.

In this way, you can link both DPV0 and DPV1 slaves to PROFINET.

Additional information

For information on the differences and common features of PROFINET IO and PROFIBUS DP and information on migrating from PROFIBUS DP to PROFIBUS IO, refer to the From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) programming manual.

2.5 PROFINET IO and PROFINET CBA

What is PROFINET IO?

As part of PROFINET, PROFINET IO is a communication concept that is used to implement modular, distributed applications.

PROFINET IO allows you to create automation solutions of the type with which you are familiar from PROFIBUS DP.

PROFINET IO is implemented using the PROFINET standard for programmable controllers (IEC 61158-x-10).

The STEP 7 engineering tool helps you to structure and configure an automation solution.

In STEP 7 you have the same application view, regardless of whether you are configuring PROFINET devices or PROFIBUS devices. The user program for PROFINET IO and PROFIBUS DP looks the same. The same system function components and system state lists are used (were expanded for PN IO).

Additional information

For information on new and changed blocks and system status lists, refer to the From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) programming manual.

What is PROFINET CBA?

As part of PROFINET, PROFINET CBA (Component Based Automation) is an automation concept that focuses on the following:

- Implementation of modular applications
- Machine - machine communication

PROFINET CBA lets you create distributed automation solutions based on off-the-shelf components and partial solutions. This concept satisfies demands for a higher degree of modularity in the field of mechanical and systems engineering by extensive distribution of intelligent processes.

With Component Based Automation you can implement complete technological modules as standardized components that can be used in large systems.

You create the modular, intelligent components of the PROFINET CBA in an engineering tool, which may differ according to the device manufacturer. Components that are formed from SIMATIC devices are created with STEP 7, and are interconnected using the SIMATIC iMAP tool.

Interaction between PROFINET IO and PROFINET CBA

PROFINET CBA is used to integrate PROFINET IO systems into machine-to-machine communication. A PROFINET component is created from a PROFINET IO system in STEP 7, for example. With SIMATIC iMap, you can configure systems consisting of several such components. The communication connections between the devices are configured simply as interconnection lines.

The following graphic illustrates a distributed automation solution with several components which communicate via PROFINET. The components on the right have IO devices and an IO controller on PROFINET IO.
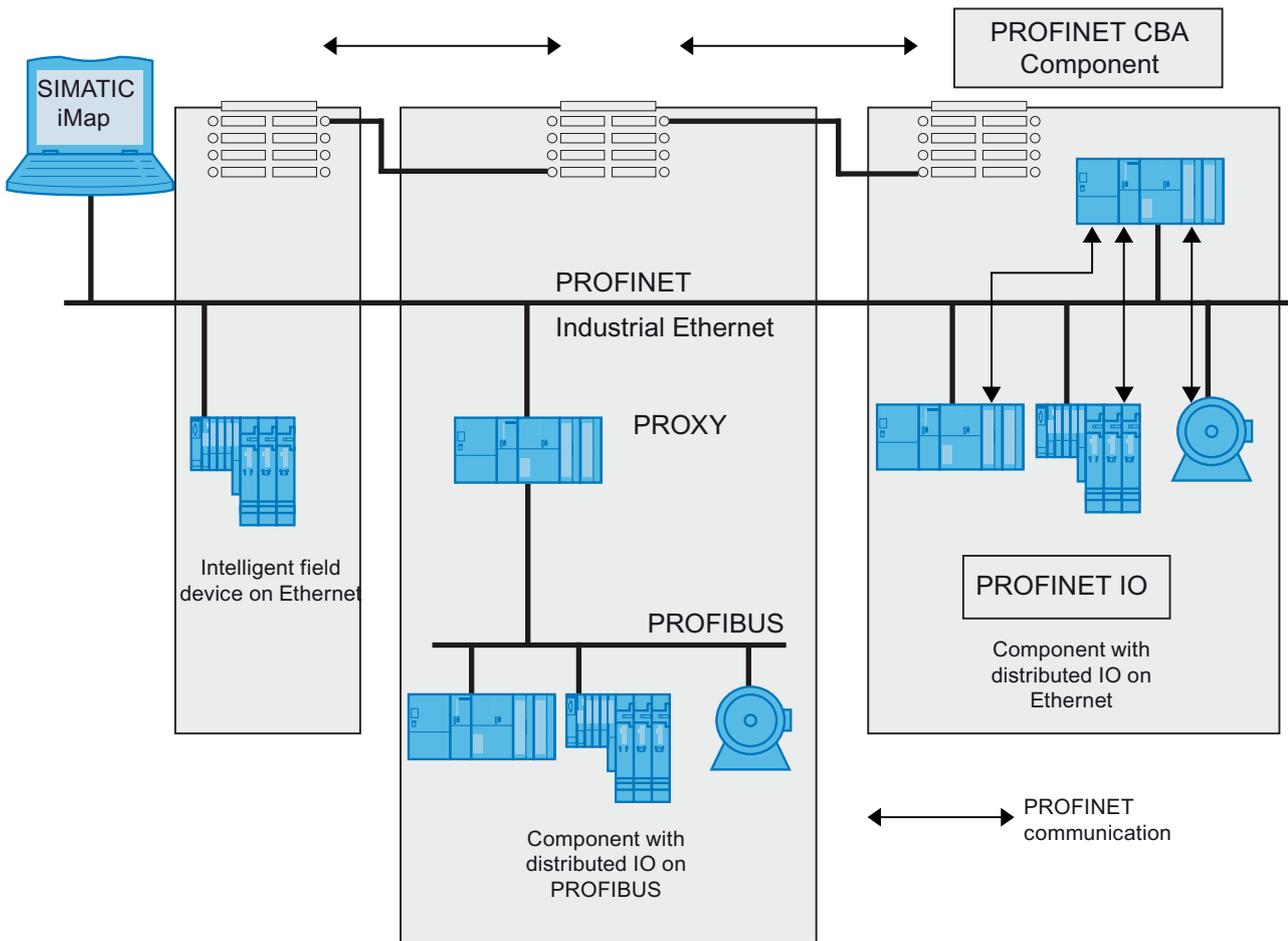
Figure 2-6   PROFINET CBA - modular concept

Differentiation between PROFINET IO and PROFINET CBA

PROFINET IO and CBA are two different ways of looking at programmable controllers on Industrial Ethernet.
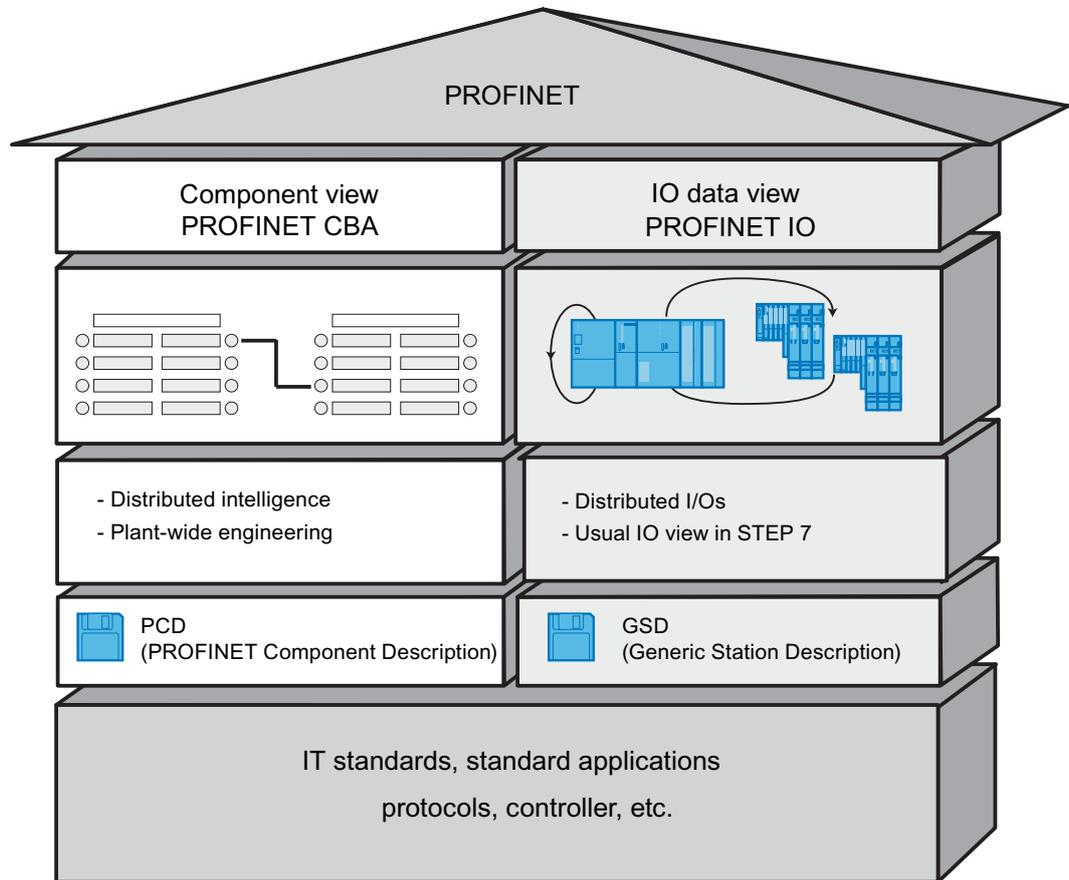
Figure 2-7   Differentiation between PROFINET IO and PROFINET CBA

Component Based Automation breaks the overall system down into various functions. These functions are configured and programmed.

PROFINET IO provides you with a picture of the plant that is very similar to the view obtained in PROFIBUS. You continue to configure and program the individual programmable controllers.

## Controllers in PROFINET IO and PROFINET CBA

You can also use some PROFINET IO controllers for PROFINET CBA.

The following PROFINET devices also support PROFINET CBA:

- Programmable logic controllers,
  - ET 200S CPU IM151-8 starting with firmware version V2.7
  - ET 200pro CPU IM154-8 starting with firmware version V2.5
  - S7-300 CPU 31x-2 PN/DP, firmware version V2.3 or later
  - S7-300 CPU 319-3 PN/DP, firmware version V2.4.0 or later
  - S7-400 CPU 41x-3 PN/DP, firmware version V5.0 or later
  - SIMATIC WINAC RTX starting with 2008 version (with CP 1616)
- CP 443-1 Advanced with the MLFB 6GK7443-1GX20-0XE0, version V2.0 or later
- CP 343-1 Advanced with the MLFB 6GK7343-1GX30-0XE0, version V1.0 or later

The following PROFINET devices support exclusively PROFINET IO:

- CP 443-1 with the MLFB 6GK7443-1EX20-0XE0, version V1.0 or later
- CP 343-1 with the MLFB 6GK7343-1EX30-0XE0, firmware V2.0 or later
- PCs that are linked to a PROFINET IO-compatible CP (CP 1616 for example) or via SOFTNET PN IO (with CP 1612 for example). With the CP 1616 and SOFTNET PN IO, the user program runs in the CPU of the PC.
- SIMOTION devices for particularly stringent real-time requirements.

Proxy in PROFINET IO and PROFINET CBA

The proxies for PROFINET IO and proxies for PROFINET CBA are different.

In PROFINET IO, the proxy for PROFINET IO represents each connected PROFIBUS DP slave as a **PROFINET IO device** on the PROFINET.

In PROFINET CBA, the proxy for PROFINET CBA represents every connected PROFIBUS DP slave as one **component,** which can participate in PROFINET communication.

Linking PROFIBUS devices via an IE/PB link

Please note that proxy functionality is available in both PROFINET IO and PROFINET CBA. For the IE/PB link, this means that you must use different devices depending on the system you are using.

Configuring and Integrating Components and Devices in PROFINET Communication

In Component Based Automation, an interconnection editor is used to incorporate the components (SIMATIC iMap for example). The components are described in a PCD file.

With PROFINET IO, the devices are incorporated using an engineering system (STEP 7 for example). The devices are described in a GSD file.

Software for PROFINET IO and PROFINET CBA

PROFINET IO integrates field devices (IO devices) into PROFINET. The input and output data of the IO devices is processed in the user program. The IO devices with their IO controller can, in turn, be part of a component in a distributed automation structure.

Communication between a CPU as the IO controller and the assigned IO devices as PROFINET IOs is configured in the same way as for a PROFIBUS DP master system in STEP 7. The user program is also created in STEP 7. From the entire PN IO system, you create a component in STEP 7 (see Figure PROFINET CBA).

You then configure communication between the components in user-friendly SIMATIC iMAP.

Note

CBA und IRT

The simultaneous usage of PROFINET CBA and IRT communication is only possible with the IRT-option "high flexibility".

Details of the possible uses of the individual products

See also the documentation for the product concerned.

2.6 SIMATIC PC stations

SIMATIC PC station

A "PC station" is a Programming device / PC / IPC with communication modules and software components within a SIMATIC automation solution.

The hardware configuration of a PC station can be compared with the configuration of an S7 controller in STEP 7.
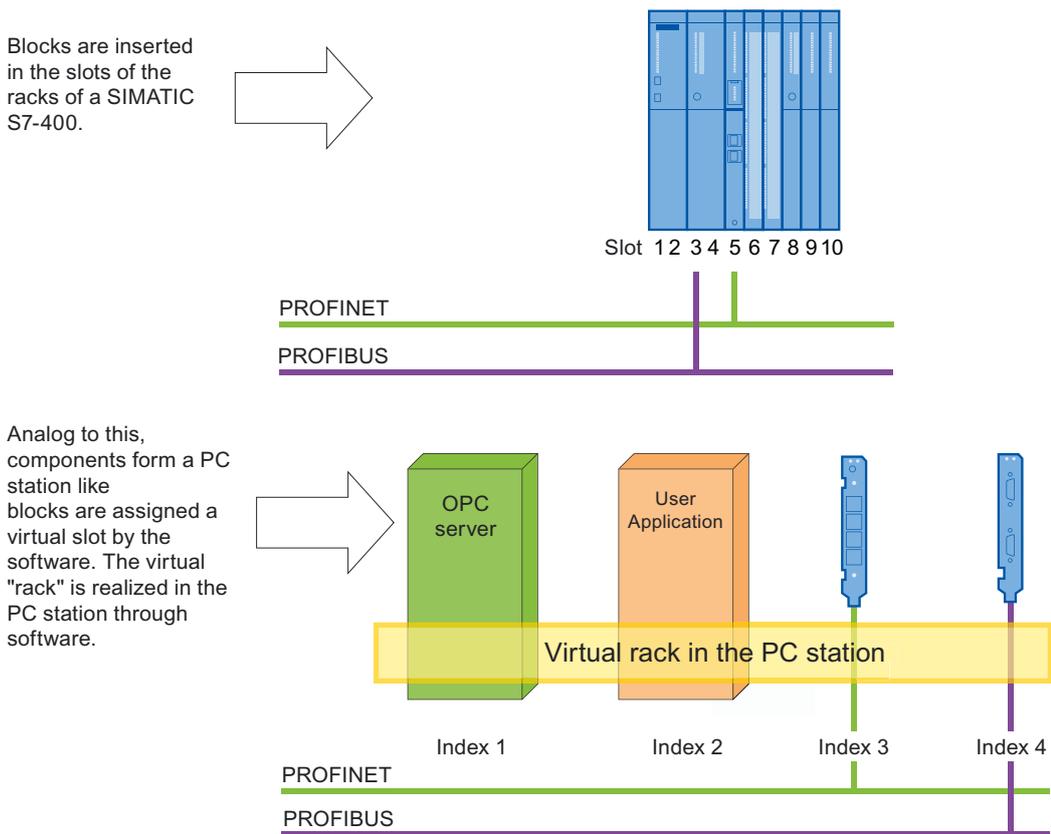

Figure 2-8   Virtual rack

Software - The OPC server as central component

A PC station contains SIMATIC NET communication modules / communication functions and software applications. The SIMATIC NET OPC server is a typical software application that allows other application programs to communicate. The user application software is based on the offered user interfaces of the SIMATIC software products installed in the PC station.

Uniform engineering environment

During configuration with STEP 7 / NCM PC, you handle the PC station as you would a SIMATIC S7 controller: You connect S7 stations and PC stations to the networks in the network view and specify the communication connections. The following figure gives you an example of how a configured PC station is shown in NetPro with STEP 7 and NCM PC.
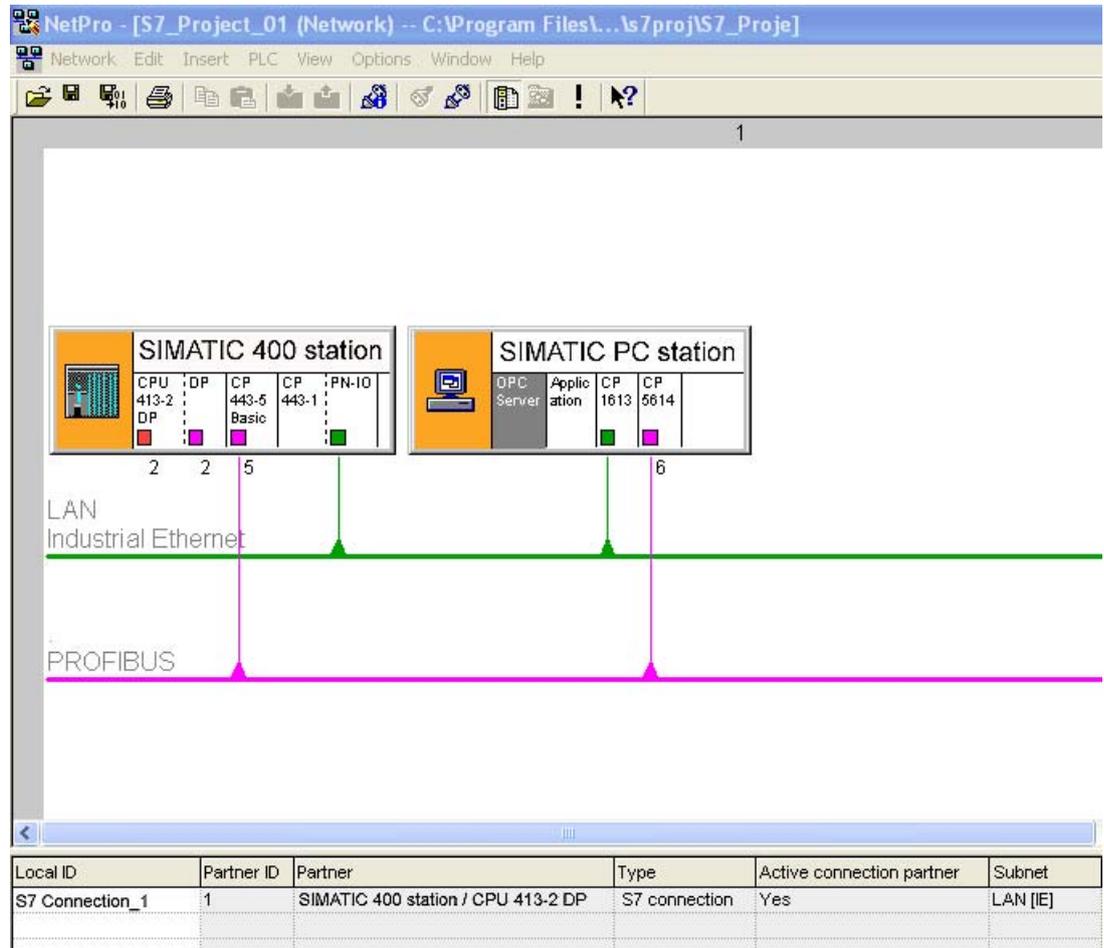

Figure 2-9   STEP 7 - NetPro

PC Station as PROFINET IO Controller

By using suitable communication modules and software components you can operate a PC station as a PROFINET IO controller.

Your PC applications in the PC station have the following methods of accessing the PROFINET IO-controller:

● As an OPC client via the OPC server, e.g. in SOFTNET PROFINET IO
   (OPC: Object Linking and Embedding (OLE) for Process Control)

● Directly via the PROFINET IO Base user interface

● Through a WinAC with Ethernet submodule (for example, CP1616)

At any point in time you have always just one of these access possibilities from a PC application.
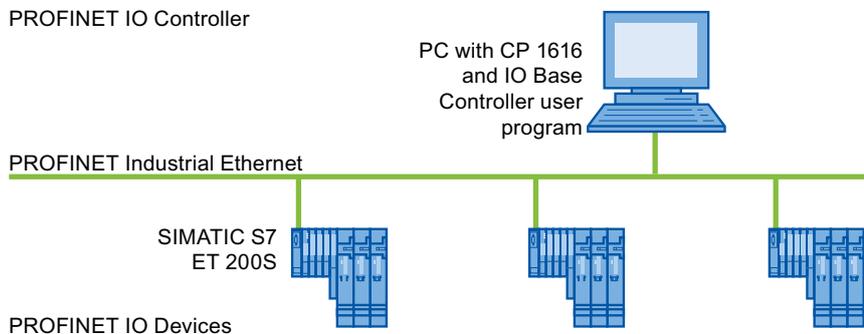
Figure 2-10   CP 1616 as PROFINET IO controller

Components of a PC Station

The following schematic shows a PC station with the described components.
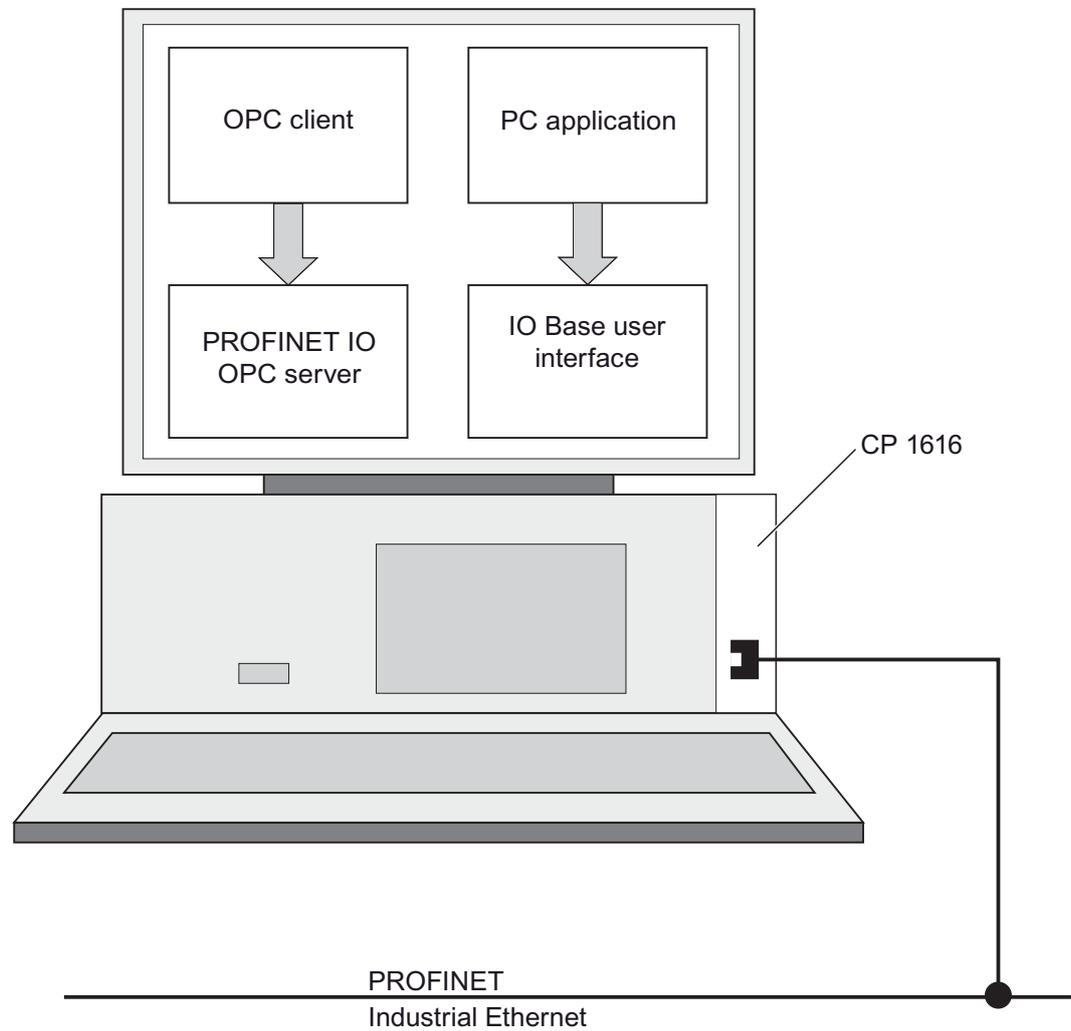
Figure 2-11   SIMATIC PC station

See also

SIMATIC NCM PC (Page 212)

Setting Up PROFINET 3

Content of this section

This section contains background information about the structure of your communication network. Specifically, it contains:

- An overview of the most important passive network components: these are network components (cables, connectors, etc.) that forward a signal without being able to actively influence that signal.

- An overview of the most important active network components: these are network components (switches, routers, etc.) that actively influence a signal.

- Overview of the most common network structures (topologies).

- Structural guidelines to help you further improve the performance of your PROFINET.

3.1   Introduction

Physical connections of industrial networks

PROFINET devices can be networked in industrial systems in two different physical ways:

- Connected line
  - By means of electrical pulses via copper cables
  - By means of optical pulses via fiber-optic cables
- Wireless via wireless network using electromagnetic waves

3.2 Wired networks

3.2.1 Technology

Fast Ethernet

With Fast Ethernet you can transfer data at a speed of 100 Mbps. This transmission technology uses the standard 100 Base-T.

Industrial Ethernet

Industrial Ethernet is a directive for connecting to an Ethernet in an industrial environment. The greatest difference to standard Ethernet is in the mechanical capacity and the immunity to interference for the individual components.

3.2.2 Network elements

3.2.2.1 Cabling technology

Cables for PROFINET

You have the option of using electrical or optical cables, depending on the data transmission requirements and the environment in which the cables are used.

Technical specifications of the interface

Information about the technical specifications of the interface can be found in the PROFINET interface with integrated switch (Page 20) chapter.

Simple method for making up twisted pair cables

When you set up your PROFINET system, you can cut the AWG 22 twisted pair cable on-site to the required length, strip it with the *Stripping Tool* (for Industrial Ethernet), and fit the *Industrial Ethernet Fast Connect RJ45-Plugs* using the cut-and-clamp technique. For additional information on installation, refer to the Assembly Instructions for SIMATIC NET Industrial Ethernet (http://support.automation.siemens.com/WW/view/en/27069465) product information.

NOTICE
A maximum of 6 connections are allowed per Ethernet path.

Simple making up of fiber-optic cables

The cabling system of FastConnect FO is available for the simple, quick and error-free making up of fiber-optic cables. It comprises:

- FC FO Termination Kit for SC and BFOC plug
  (cleave tool, Kevlar scissors, buffer grip, fiber remains container)

- FC BFOC plug

- FC SC Duplex Plug

- FO FC Standard Cable

- FO FC trailing cable

Simple method for making up POF and PCF cables

The following special tools provide an easy and safe way to prepare POF / PCF cables and fit the SC RJ POF plugs:

- POF cable

  Installation case: IE termination kit SC RJ POF plug

- PCF cable

  Installation case: IE termination kit SC RJ PCF plug

Data transmission rate

The PROFINET interfaces in our devices are preset to a default "automatic setting" (Autonegotiation). Ensure that all devices connected to the PROFINET interface of an S7-CPU are also set to the "Autonegotiation" operating mode. This is the default setting of standard PROFINET / Ethernet components.

If you change the default setting "Automatic setting" (Autonegotiation), please note the following information:

Note

Data transmission rate of the PROFINET interface

PROFINET IO and PROFINET CBA require operation with 100 Mbps full-duplex, i.e. when the on-board PROFINET interface(s) of the CPU for PROFINET IO/CBA communication and Ethernet communication is(are) used at the same time, alongside the "Automatic setting" (Auto negotiation) the PROFINET interface(s) can only be operated with 100 Mbps full-duplex.

Reason: If, for example, a switch is connected which is fixed to "10 Mbps half duplex", the PROFINET device with integrated PROFINET interface adapts to the setting of the partner device by means of the "Autonegotiation" setting. In this case, communication takes place de facto with "10 Mbps half duplex". However, this operating mode is not allowed because PROFINET IO and PROFINET CBA require operation at 100 Mbps full-duplex.

Additional information

For more detailed information, see the SIMATIC NET Twisted Pair and Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736) SIMATIC NET manual.

You should also read the PROFINET Installation Guideline (http://www.profibus.com/nc/downloads/downloads/profinet-installation-guide/display/) publication from PROFIBUS International.

3.2.2.2 Active Network Components

Network components in wired networks

The following active network components are available for PROFINET:

- Switch
- Router

Switch

Switches are available in two models:

- As external switches in a personal casing.
- As an integrated switch in a S7-CPU, a S7-CPs or a distributed IO system ET 200.

If a communication node is to be connected to several other communication nodes, this communication node is connected to the port of a switch. Other communication nodes (including switches) can then be connected to the other ports of the switch. The connection between a communication node and the switch is a point-to-point connection.

The task of a switch is therefore to regenerate and distribute received signals. The switch "learns" the Ethernet address(es) of a connected PROFINET device or additional switches and only forwards those signals that are intended for the connected PROFINET device or switch.

In our SCALANCE X device family you will find switches with electrical and optical ports or with a combination of both variants. The SCALANCE X202-2IRT, for example, has 2 electrical ports and 2 optical ports and supports IRT communication.

With STEP 7, you can configure and perform diagnostics on and address switches from the SCALANCE X device family as PROFINET IO devices.

Note

Assigning IP addresses

You can also use the Primary Setup Tool (PST) to assign IP addresses to several PROFINET devices as an alternative to STEP 7.

Switches in PROFINET

Use the switches of the SCALANCE product family if you want to use the full scope of PROFINET. They are optimized for use in PROFINET IO.

Router

A router works in a similar way to a switch, so as to connect networks to one another (e.g. office network with automation network). With a router, however, you can also specify which communication nodes may communicate via the router and which may not. Communication nodes on different sides of a router can only communicate with one another if you have explicitly enabled communication between them via the router.

The high level of communication traffic on an office Ethernet could impair communication in an Industrial Ethernet. The router prevents this and limits the load on the network.

If you want to access manufacturing data directly from SAP, for example, use a router to connect your Industrial Ethernet in the factory with the Ethernet in your office.

A router thus represents the boundary of a network.

Note

Router and PROFINET IO

The communication with PROFINET IO is limited to a subnetwork. Since a router limits a subnetwork, no communication with PROFINET IO is possible. For PROFINET CBA; only acyclic connections are possible.

The CP 343-1 Advanced and CP 443-1 Advanced communications processors implement integral network separation between the control level and field level and provide the following advantages:

- Separate network connections for the control level (Gigabit Ethernet) and the field level (Fast Ethernet) on a module

- Cross-network utilization of IT services through IP routing, such as access to web servers

- Access protection via a configurable IP access list

SIMATIC components with security functions

Linking industrial Ethernet to both an intranet and the Internet requires solutions that will protect against internal and external threats.

The SIMATIC NET Industrial Security components from the SCALANCE S product family offer ideal defense mechanisms against attacks, espionage, manipulation and unauthorized access at all network levels. They have numerous features such as encryption, authentication and access control for up to 128 channels for setting up a virtual private network (VPN) and an integrated firewall.

The modules contain a configuration plug for configuration data that you insert in the replacement device in the event of a fault. The data is automatically accepted by the new device, so no programming device/PC is needed for programming if a replacement becomes necessary. The VPN Software SOFTNET security client helps you set up secure communication.

The Security Configuration Tool (SCT) provides you with a configuration tool which can be used to configure all SCALANCE S in a system.

Furthermore, countless other SIMATIC products offer integrated security functions as well:

Communication processors like the SIMATIC CP 343-1 Advanced and Industrial Ethernet Switches like SCALANCE X-300 support procedures for the authentication of network participants and for protection from unauthorized access on CPUs and the network.

Additional information

Manuals:

- SIMATIC NET Twisted Pair and Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736)

- SCALANCE S and SOFTNET Security Client (http://support.automation.siemens.com/WW/view/en/21718449).

Download:

- Primary Setup Tool (http://support.automation.siemens.com/WW/view/en/19440762)

You should also read the following publications from the PROFIBUS user organization:

- PROFINET Installation Guideline (http://www.profibus.com/nc/downloads/downloads/profinet-installation-guide/display/)

- PROFINET Security Guideline (http://www.profibus.com/nc/downloads/downloads/profinet-security-guideline/display/)

- PROFIsafe - Environmental Requirements (http://www.profibus.com/nc/downloads/downloads/profisafe-environmental-requirements/display/)

3.3 Wireless networks

3.3.1 Basics

Data transmission rate

In Industrial Wireless LAN, gross data transmission rates of 11 Mbps or 54 Mbps without full duplex are permitted.

Interface

Table 3- 1   Technical specifications of radio interface

Physical properties	Connection methods	Cable type / transmission medium standard	Transmission rate / mode	Advantages
Radio bands	-	IEEE 802.11	Depending on the expansion used (a / b / g / h etc.)	Greater mobility Cost-effective networking to remote, difficult to access nodes

Range

With SCALANCE W (access points), wireless networks can be set up indoors and outdoors. Multiple access points can be installed to create large wireless networks in which mobile subscribers are transferred seamlessly from one access point to another (roaming).

As an alternative to a wireless network, point-to-point connections of Industrial Ethernet segments can also be set up over large distances (several hundred meters). In this case, the range and characteristics of the wireless hop are determined by the antennas used.

Note

Range

The range can be considerably less, depending on spatial factors, the wireless standard used, the data rate, and the antennas on the send and receive sides.

What is Industrial Wireless LAN?

In addition to data communication to IEEE 802.11, SIMATIC NET Industrial Wireless LAN provides a number of extremely useful enhancements (ifeatures) for the industrial customer. IWLAN is particularly suited for complex industrial applications with requirement for reliable radio communication, owing to the following properties:

- Automatic roaming when the connection to Industrial Ethernet is interrupted (Forced Roaming)

- Cost savings generated by using a single wireless network for secure operation of a process with both process-critical data (alarm message, for example) and non-critical communication (service and diagnostics, for example)

- Cost-effective connection to devices in remote environments that are difficult to access

- Predictable data traffic (deterministic) and defined response times

- For use in hazardous areas of Zone 2

- Cyclical monitoring of the wireless link (link check)

Aims and advantages of Industrial Wireless LAN

Wireless data transmission achieves the following objectives:

- Seamless integration of devices into the existing bus system via the wireless interface

- Mobile use of devices for different production-linked tasks

- Flexible configuration of the system components for fast development in accordance with customer requirements

- The node can be accessed at all times within the entire network

- Protection against unauthorized network nodes by means of address tables, authorization and changing keys.

Application examples

- Reliable use of products that have to meet stringent temperature and mechanical stability requirements

- Local access to service and maintenance schedules

- Communication with mobile subscribers (mobile controllers and devices, for example), high bay storage and retrieval devices, conveyor lines, production belts, translation stages, and rotating machines

- Wireless coupling of communication segments for fast commissioning or cost-effective networking where routing of wires is extremely expensive (e.g. public streets, railroad lines, for example)

- Automated guided vehicle systems and suspended monorail systems

The following graphic illustrates the many possible applications and configurations for SIMATIC device family wireless networks.
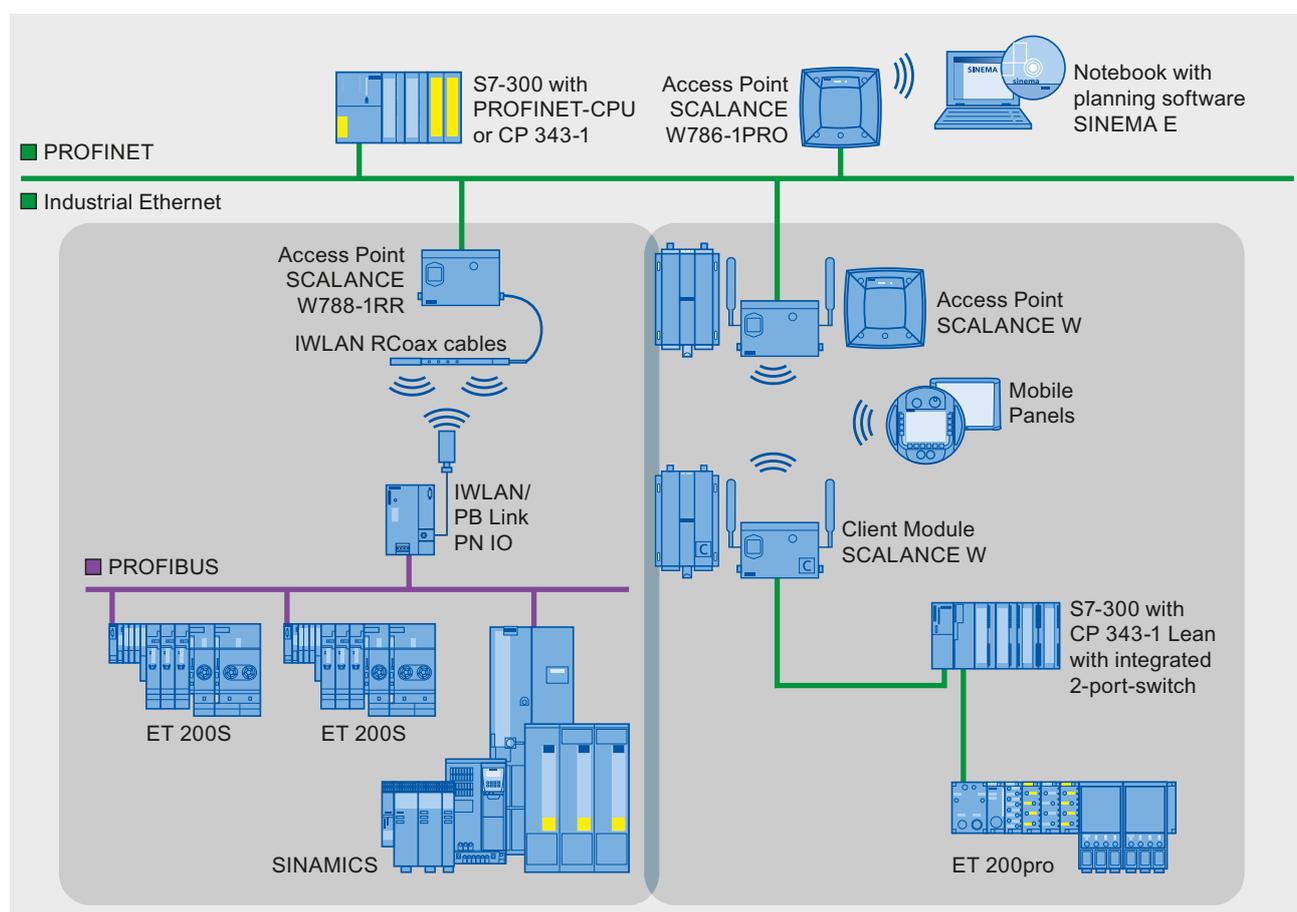
Figure 3-1   Possible application examples for Industrial Wireless LAN

Industrial Wireless LAN in interaction with PROFINET functions

> **Note**
>
> **IWLAN and IRT**
>
> PROFINET devices which are connected to Access Points on PROFINET IO do not support IRT.

> **Note**
>
> **IWLAN and prioritized startup**
>
> PROFINET devices which are connected to Access Points on PROFINET IO do not support the "Prioritized startup" PROFINET function.

3.3.2 Industrial Wireless LAN

Wireless networks, SCALANCE device family

With PROFINET, you can also set up wireless networks with Industrial Wireless Local Area Network (Industrial WLAN) technology. We recommend implementing the SCALANCE W device line for this.

Update time in STEP 7

If you set up PROFINET with Industrial Wireless LAN, you may have to increase the update time for the wireless devices. The IWLAN interface has a lower performance than the wired data network, because the restricted bandwidth needs to be divided over several communication nodes. For wired solutions, the communication nodes have available the "full" 100 Mbps.

You will find the update time parameters in STEP 7 / HW Config in the object properties of the PROFINET IO system.

Configuring and Setting Parameters for SCALANCE W

To configure and carry out parameter settings for the first time, use the web interface.
To assign an IP address, you will need either the Primary Setup Tool (PST) or STEP 7.

Planning, simulating and configuring with SINEMA E

SINEMA E (SIMATIC Network Manager Engineering) is planning, simulation and configuration software that simplifies the task of installing and starting up a WLAN network with the help of simulation functions.

- Planning a WLAN infrastructure

  By modeling the environment - external area, internal area etc., you can calculate the distribution of the electromagnetic fields. One the basis of this calculation you then position the access points and align their antennas.

- Simulating a WLAN infrastructure

  Simulating the planned wireless LAN allows you to calculate the position, range and attenuation without having to construct the LAN first. Simulation allows you to work out the optimum sending and receiving conditions when setting up a WLAN structure.

- Configuring a WLAN infrastructure

  You configure the WLAN devices offline and save all the relevant data (parameters, security settings) in a project. When online, all the WLAN devices are automatically conveyed via the LAN and the configured parameters are downloaded to the WLAN devices.

- Measurements for optimizing and maintaining a WLAN infrastructure

  You can support measurements and analyses at the start of planning with the optimal illumination of an available WLAN network. In addition, the measurements give important information in troubleshooting and maintenance.

- Report function

  Alongside the documentation of the measurement results, use the extensive report function for drawing up offers (Sales Wizard), for installation (device installation instructions), for acceptance, troubleshooting and expanding the WLAN network.

Additional information

More information about SCALANCE W industrial wireless LAN components can be found in the manual SIMATIC NET SCALANCE W-700 (http://support.automation.siemens.com/WW/view/en/42784493).

For more detailed information on wired data transmission, refer to the SIMATIC NET Twisted Pair and Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736) SIMATIC NET manual.

More information about wireless data transmission can be found in the manual Basics for configuring an industrial wireless LAN (http://support.automation.siemens.com/WW/view/en/9975764)

A free download of the primary setup tools can be found online (http://support.automation.siemens.com/WW/view/en/19440762).

Downloads for the SINEMA E Lean and SINEMA E standard software can be found on the Internet (http://support.automation.siemens.com/WW/view/en/23775917).

You should also read the PROFINET Installation Guideline from the PROFIBUS User Organization on the Internet (http://www.profibus.com/nc/downloads/downloads/profinet-installation-guide/display/).

3.4 Data security in automation

3.4.1 Basics

Introduction

The topic of data security and access protection (Security) have become increasingly important in the industrial environment. The increased networking of entire industrial systems, vertical integration and networking of levels within a company and new techniques such as remote maintenance have all served to increase vulnerability.

Data security solutions for office environments cannot simply be transferred one-to-one to industrial applications to protect against manipulation in sensitive systems and production networks.

Requirements

Additional security requirements arise from the specific communication requirements in the industrial environment (real-time communication, for example):

- Protection against interaction between automated cells
- Protection of network segments
- Protection against unauthorized access
- Scalability of security functionality
- Must not influence the network structure

Definition of security

Generic term for all the measures taken to protect against

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability due to the destruction of data

Threats

Threats can arise from external and internal manipulation. The loss of data security is not always caused by intentional actions.

Internal threats can arise due to:

- Technical errors
- Operator errors
- Defective programs

Added to these internal threats there are also external ones. The external threats are not really any different to the known threats in the office environment:

- Software viruses and worms
- Trojans
- Unauthorized access
- Password Phishing

  In password phishing, the phisher masquerades as a trustworthy person or business in order to get the recipient of an email to disclose access data and passwords.

Precautions

The most important precautions to prevent manipulation and loss of data security in the industrial environment are:

- Filtering and inspection of the data traffic by means of Virtual Private Networks (VPN)

  A virtual private network is used to exchange private data on a public network (Internet, for example). The most common VPN technology is IPsec. IPsec is a collection of protocols that use the IP protocol on the network layer.

- Segmenting in protected automation cells

  This concept has the aim of protecting the network nodes by means of security modules. A group of protected devices forms a protected automation cell. Only security modules from the same group or the devices they are protecting can exchange data with one another.

- Authentication (identification) of the nodes

  The security modules identify each other over a safe (encrypted) channel using authentication procedures. It is therefore impossible for unauthorized parties to access a protected segment.

- Encrypting the data traffic

  The confidentiality of data is ensured by encrypting the data traffic. Each security module is given a VPN certificate which includes the encryption key.

3.4.2 Network components and software

Protection against unauthorized access

The following solutions may be used to connect industrial networks to the intranet and Internet to protect against internal and external threats:

- SCALANCE S - the data security components of the SIMATIC NET product family
- SOFTNET Security Client for use on PCs

Features

Both of these products have a wide variety of features, such as:

- Encrypted communication,
- Authentication
- Access control for up to 128 channels in order to set up a Virtual Private Network (VPN)
- Easy integration of existing networks without configuration, with integrated firewall.

The modules contain a memory card (configuration plug) for the configuration data. In the event of a fault this memory card is inserted into the replacement device. The data is automatically accepted by the new device, so no PG/PC is needed for programming if a replacement becomes necessary.

On the PC side, the SOFTNET Security Client helps you set up secure communication. With the Security Configuration Tool (SCT), software is provided with which you can configure SCALANCE S and create the certificates for the VPNs.

3.4.3 Guidelines for information security in the industrial automation

VDI Guideline

With the "VDI/VDE 2182 sheet 1", Information Security in the Industrial Automation - General procedural model, VDI guideline, the VDI / VDE society for measuring and automation engineering has published a guide for implementing a security architecture in the industrial environment. The guideline can be found on the Homepage of the VDI organization (http://www.vdi.de/en/vdi/vrp/richtliniendetails_t3/?&no_cache=1&tx_vdirili_pi2[showUID]=89 853&L=1).

PROFINET Security Guideline

The PROFIBUS user organization can support you in setting up security standards in your company by means of the PROFINET Security Guideline. These guidelines can be found on the homepage of the PROFIBUS User Organization under downloads online (http://www.profibus.com).

3.4.4 Application example

Data security at the office and production levels

The following graphic contains an application example with protected areas at different levels of the company created using SCALANCE S and the security client. The protected areas are highlighted in light gray.
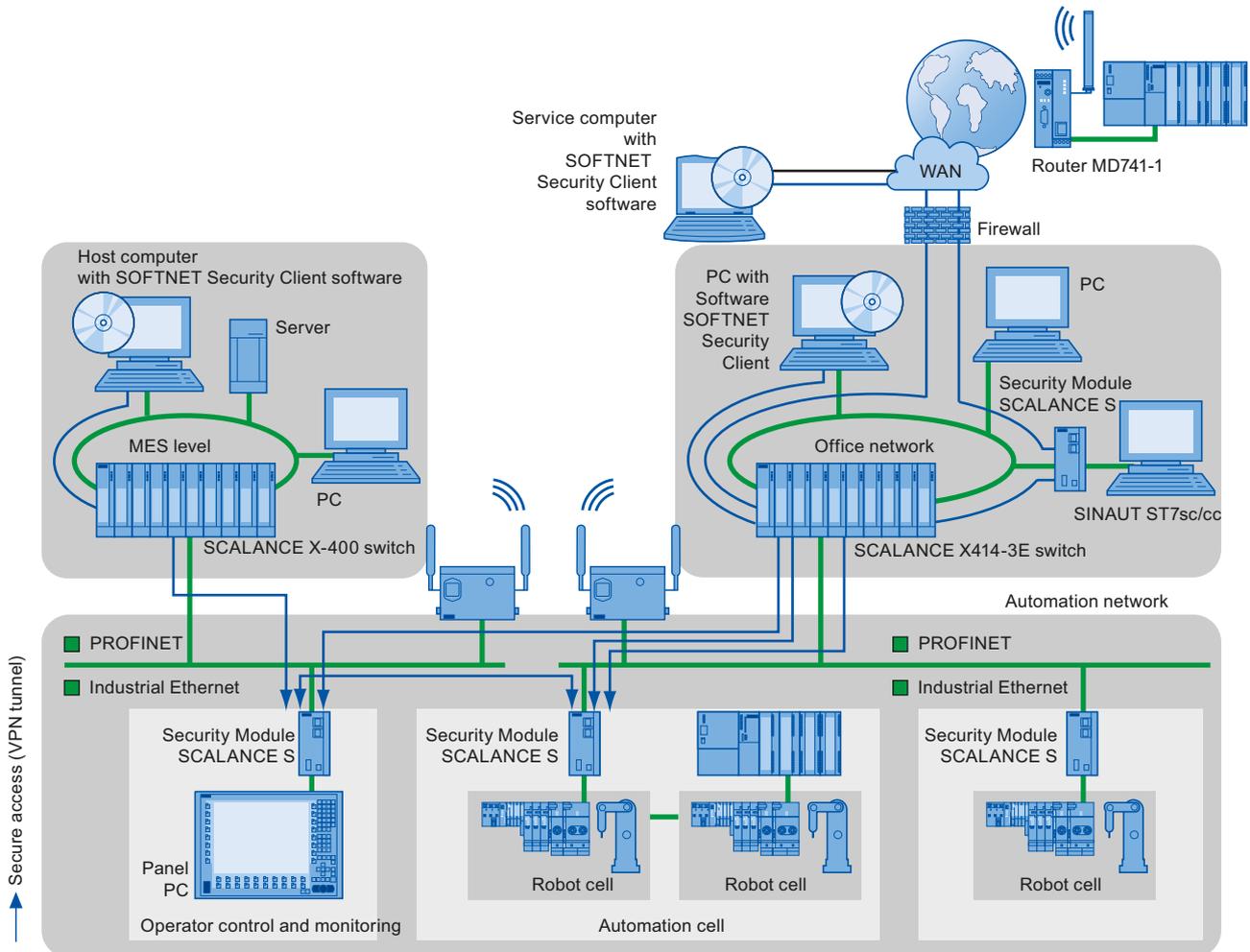
Figure 3-2   Network setup with the SCALANCE S security module and the SOFTNET security client

Additional information

More detailed information on setting up a security standard in PROFINET can be found in the PROFINET Security Guideline. These guidelines can be found on the homepage of the PROFIBUS User Organization at Internet (http://www.profinet.com).

3.5 Topology

An overview of various options for setting up a PROFINET network is given below.

Star

If you connect communication nodes to a switch with more than two PROFINET ports, you automatically create a star network topology.

If an individual PROFINET device fails, this does not automatically lead to failure of the entire network, in contrast to other structures. It is only if a switch fails that part of the communication network will fail as well

Tree

If you interconnect several star structures, you obtain a tree network topology.

Linear

All the communication nodes are connected in a linear bus topology.

If a link element (switch, for example) fails, communication across the failed link element is no longer possible. The network is then divided into 2 subsegments.

In PROFINET, the linear bus topology is realized with switches that are already integrated into the PROFINET devices. Therefore, the linear bus topology at PROFINET is merely a special form of tree / star topology.

Linear bus topology structures require the least wiring.

Ring

In order to increase the availability of a network, use ring structures. In principal, a linear topology is connected to a ring through a so-called redundancy manager.

The task of the redundancy manager is taken over by an external switch (SCALANCE X) or a CPU, which supports the media redundancy protocol (MRP)(S7-300 V3.2, S7-400 V6.0, WinAC RTX 2010 with CP1616).

If there is a break in the network, the redundancy manager ensures that the data is redirected over an intact network connection.

Network

All the devices interconnected by switches are located in one and the same network. All the devices in a network can communicate directly with each other.

All devices in the same network have the same subnet mask.

A network is physically limited by a router.

NOTICE
If devices need to communicate beyond the limits of a network, you must configure the router so that it allows this communication to take place.

The communication from PROFINET IO functions exclusively within a network. You have the option of connecting various PROFINET IO networks via PN/PN coupler. |

Additional information

For more detailed information, see the SIMATIC NET Twisted Pair and Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736)SIMATIC NET manual.

You should also read the PROFINET Installation Guideline from the PROFIBUS User Organization (http://www.profibus.com/nc/downloads/downloads/profinet-installation-guide/display/).

For more detailed information, see the Communication with SIMATIC (http://support.automation.siemens.com/WW/view/en/1254686) manual.

3.6   Topology examples

Topology examples

The following example shows various topologies combined.
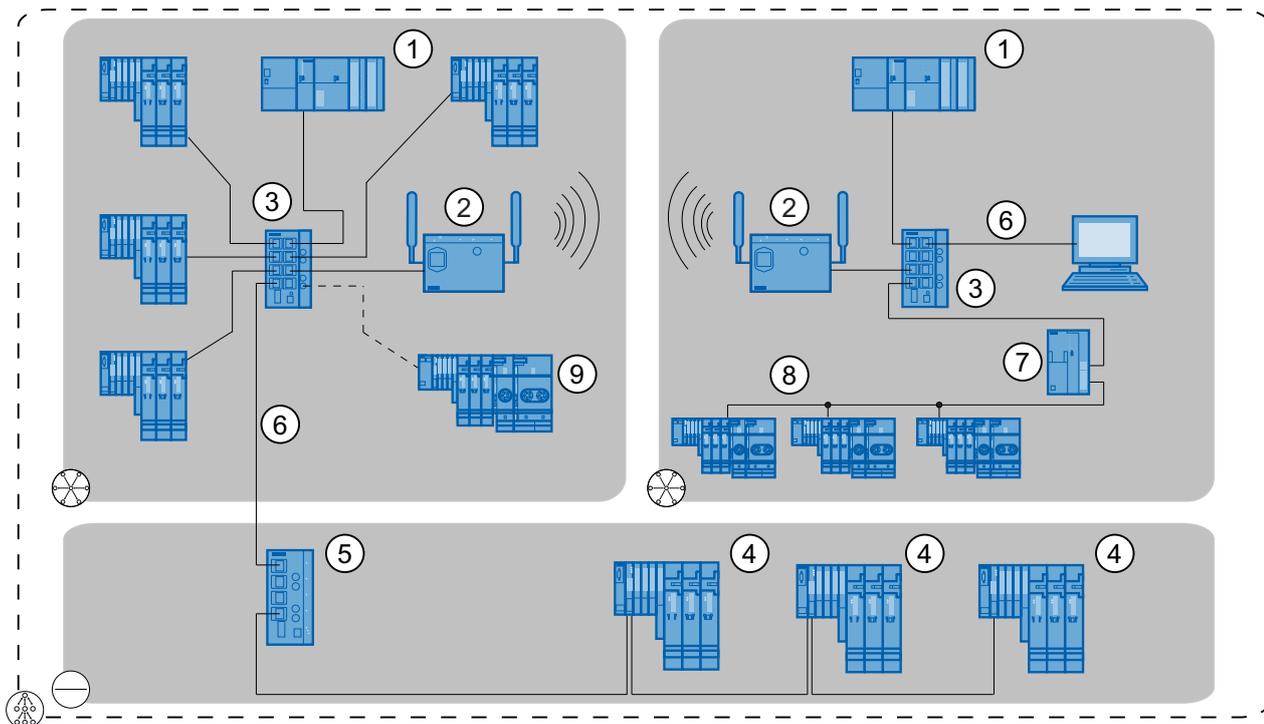
Number	Meaning
①	S7-300 as IO controller
②	Industrial WLAN with SCALANCE W; wireless connections
③	SCALANCE X 208 with 8 electrical ports
④	ET 200S distributed I/O system with integrated multi-port switch, so that you can connect additional PROFINET devices and thus implement a linear bus topology.
⑤	SCALANCE X 204 -2 with 4 electrical and 2 optical ports
⑥	PROFINET / Industrial Ethernet
⑦	IE/PB - Link PN IO
⑧	PROFIBUS DP
⑨	ET 200S distributed I/O system with 2 optical ports
⊕	Star topology
⊖	Linear bus topology
⊛	This combination of different topologies creates a tree topology.

Figure 3-3   Combined topology

PROFINET functions

<div style="text-align: right">

4

</div>

Content of this section

In this chapter, you will receive information about the basic terms for communication, technology, benefits and areas of application for real-time communication and setup recommendations for optimizing PROFINET. In addition, the following functions are described:

- Option handling
- Device replacement without removable media / PD
- Prioritized startup
- Docking Station - Changing IO devices during operation
- Shared Device
- I-device
- Isochronous mode
- PROFIenergy
- Media redundancy
- System redundancy

4.1 Basic terminology of communication

PROFINET communication

PROFINET communication takes place via Industrial Ethernet.
The following transmission types are supported:

- Acyclic transmission of engineering and diagnostics data and interrupts

- Cyclic transmission of user data

The PROFINET communication occurs in RT (real time).

Update time

Within this time interval an IO device / IO controller in the PROFINET IO system is supplied with new data by the IO controller / IO device. The send cycle can be configured separately for each IO device and determines the interval at which data are sent from the IO controller to the IO device (outputs) as well as data from the IO device to the IO controller (inputs).

Note

According to the Nyquist-Shannon sampling theorem, there is a changed value of a sensor after at latest an update cycle being executed twice in the IO controller. Further time delays can occur through back wall bus durations and analog digital conversion times in the IO device. After this time, the changed value can be accessed directly from the user program (for example, L PEW 267). If the value is accessed through the process image, the cycle time of the OB1 must be added twice.

Response check time

The response check time describes the time taken for an IO controller or IO device to be accepted, within this time no new IO data can be received. The response check time is illustrated by STEP 7 from an integral multiple of the update time and can be adapted by the user.

If the IO device is not supplied by the IO controller with input / output data within the response check time, it fails and issues substitute values. This is reported in the IO controller as a station failure.

Note

If an IO device is operated with IRT and the IRT-option "high performance", then this will fail after 180ms after recognizing a sync loss. This behavior applies independent of a larger selected contact monitoring time. Replacement values - if planned - are first turned off after the expiration of the response check time.

IRT (Isochronous Real Time, real-time communication with reserved bandwidth)

In the case of PROFINET IO with IRT, a sync master transmits a synchronization message to which all sync slaves synchronize themselves. The synchronization mechanisms will be controlled by ERTEC (Enhanced Real-Time Ethernet Controller) of the integrated PROFINET interface. This ensures a synchronization accuracy of less than one microsecond. The synchronization of all IRT-capable PROFINET devices on a common time base is the prerequisite for the scheduled communication control and the bandwidth reservation.

You assign the device roles sync master and sync slave by configuring the PROFINET devices in STEP 7, as described in chapter Configuring the real-time communication (Page 194). The role of a sync master can be assigned both to an IO controller as well as a switched configured on an IO device, provided these support the "sync master" function.

The sync master and the sync slaves together form the sync domain. A sync domain has exactly one active sync master - for the runtime.

Note

Setup recommendations for PROFINET IO with IRT

Please note the setup recommendations "Setting up PROFINET with IRT" for PROFINET IO systems within sync domains in chapter Setup recommendations for optimizing PROFINET (Page 173).

Real time and determinisms

Real-time means that a system processes external events within a defined time.

Determinism means that a system responds in a predictable (deterministic) manner.

Send clock

Period between two successive intervals for IRT or RT communication.
The send clock is the shortest possible transmit interval for exchanging data.

For IRT with the "high performance" option, in addition to the "even" transmission tact (250 µs, 500 µs, 1 ms, 2 ms, 4 ms), the send clock can be set as "odd" between 250 µs and 4 ms at any multiple of 125 µs: 375 µs, 625 µs … 3.875 ms.

With "odd" send frequencies, the following applies for all PROFINET IO-devices:

- Update time = send frequency

- no amendment of IRT with the "high performance" option possible through RT devices

Relationship between the update time and send clock

The calculated update times are step-downs (1, 2, 4, 8, ..., 512) of the send clock. The minimum possible update time thus depends on the minimum send clock of the IO controller that can be set and the efficiency of the IO controller and the IO device. Depending on the send clock, only a part of the step-downs can be available (STEP 7 guarantees this through a pre-selection).

The following tables illustrate the dependency of the update time that can be set on the send clock, using an example of the CPU 319-3 PN/DP.

Table 4- 1 The following applies to RT:

Send clock	Update time	Step-downs
250 µs	250 µs to 128 ms	1,2, ... , 512
500 µs	500 µs to 256 ms	1,2, ... , 512
1 ms	1 ms to 512 ms	1,2, ... , 512
2 ms	2 ms to 512 ms	1,2, ... , 256
4 ms	4 ms to 512 ms	1,2, ... , 128

Table 4- 2 With IRT with the "high flexibility" option, the following applies:

Send clock	Update time	Step-downs
250 µs	250 µs to 128 ms	1,2, ... , 512
500 µs	500 µs to 256 ms	1,2, ... , 512
1 ms	1 ms to 512 ms	1,2, ... , 512

Table 4- 3 With IRT with the "high performance" option, the following applies:

Send clock	Update time	Step-downs
250 µs	250 µs to 4 ms	1,2, ... , 16
500 µs	500 µs to 8 ms	1,2, ... , 16
1 ms	1 ms to 16 ms	1,2, ... , 16
2 ms	2 ms to 32 ms	1,2, ... , 16
4 ms	4 ms to 64 ms	1,2, ... , 16

For the uneven send clock, update time = send clock.

Note

Update times for the cyclical data exchange

STEP 7 automatically determines the update time on the basis of the existing hardware configuration and the resulting cyclical data traffic.

Using the "update time" dialog (under the "IO cycle" tab in the "Properties" dialog box of the IO devices) you can choose whether the update times of the IO devices should be configured automatically by STEP 7 HW Config or whether the fixed update times or a fixed factor concerning the send clock should be specified for specific IO devices.

Automatic update time

STEP 7 automatically determines the update time on the basis of the existing hardware configuration and the resulting cyclical data traffic. It is the smallest possible update time that ensures that the available bandwidth is maintained.

The smallest possible update time in a PROFINET system depends on the following factors:

- Number of PROFINET IO devices
- Topological assignment of the IO devices (in particular line depth)
- Send clock of the IO controller or the sync master
- Efficiency of the IO controller and the IO device
- Quantity of configured user data
- PROFINET IO communication traffic
  (compared to the volume of PROFINET CBA communication traffic)
- Size of the reserved bandwidth

These dependencies will be automatically considered by STEP 7 during configuration.

If "automatic update time" has been chosen, then for RT devices a minimum update time of 2 ms is specified.

Note

Fixed update time - as an option

The update time of the IO device is fixed by the user.

The setting for the update time remains the same even if the send clock has been changed.

Due to the configuration, STEP 7 already calculates optimized, i.e. short as possible update times for IO devices in RT or IRT operation. However, for individual IO devices you can set shorter update times with the setting "fixed update time". For IO devices that deliver non-critical time usage data can increase the update times
(for example, for RT devices with higher line depth).

Note

Fixed factor - as an option

You fix the reduction using which the IO device should be updated
(e.g. factor 4 for updating every fourth send clock).

The setting for the fixed factor remains the same even if the send clock has been changed. Reducing the send clock could cause error messages during the consistency checks. In this case you must increase the factor.

STEP 7 calculates (due to the configuration for IO devices with automatic update time) optimized and possible factors for the smallest possible update times of the IO devices in the RT and IRT operation.

However, for individual IO devices you can set smaller factors with the "Fixed Factor" setting. For IO devices that deliver non-critical time usage data, you can increase the factors (for example, for RT devices with higher line depth).

Sync domain

All PROFINET devices that are to be synchronized via PROFINET IO with IRT must belong to a sync domain.

The sync domain consists of precisely one sync master and at least one sync slave.
The role of the sync master is normally done by an IO controller or switch.

Non-synchronized PROFINET devices are not a part of a sync domain.

Media redundancy

Through the so-called Media Redundancy Protocol (MRP) it is possible to setup possible redundant networks. Redundant transmission links (ring topology) ensure that an alternative communication path is made available if a transmission link fails. The PROFINET devices that are a part of this redundant network form an MRP domain.

Transparent data access

Access to process data from different levels of the factory is supported by PROFINET communication. By using Industrial Ethernet, standard mechanisms of communication and information technology such as OPC/XML can now be used along with standard protocols such as UDP/TCP/IP and HTTP in automation engineering. This allows transparent access from the office world of the company management directly to the data from the automation systems at the control level and production level.
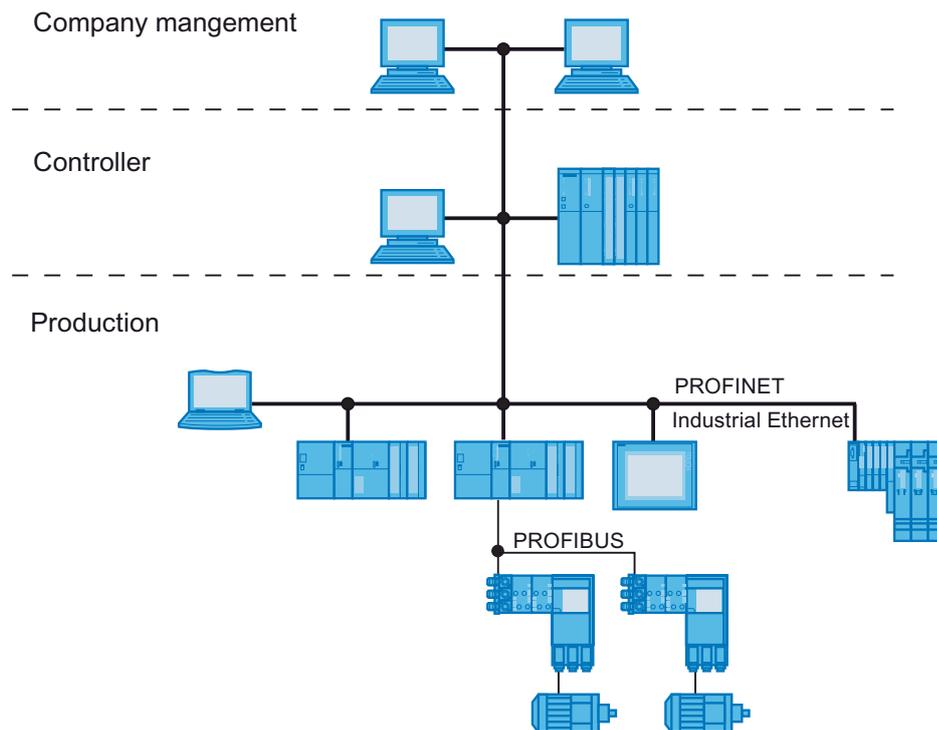
Figure 4-1   Access to process data

What are TCP/IP, COM/DCOM, OPC/XML?

You will find explanations of these terms in the glossary.

Configuring real-time communication

Information on configuring the real-time communication can be found in chapter Configuring the real-time communication (Page 194).

See also

Configuring the IRT communication of a PROFINET IO system (Page 202)

4.2 Real-time communication

4.2.1 Introduction

Real-time communication and IT communication

Industrial communication, especially in the production automation and process automation, requires a punctual and deterministic data transmission. This is why, for the cyclic exchange of time-critical IO user data, PROFINET IO does not use TCP/IP, it uses real-time communication (RT) or isochronous real-time communication (IRT) for the synchronized data exchange in reserved time intervals.

Use of PROFINET in various industries

PROFINET is used in a huge range of industries, such as:

- Production plants
- Assembly plants
- Automobile industry plants
- Plants in the food, beverage and tobacco industry
- Packing plants

Each industry has different requirements in terms of communication and its performance.

Main application of PROFINET with RT

PROFINET with RT is suitable for time-critical applications in production automation.

Main application of PROFINET with IRT

PROFINET with IRT is generally suitable for:

- Considerable performance and deterministics with large quantity structures concerning the I/O user data communication (productive data)
- Considerable performance also with many nodes in linear bus topology concerning the I/O user data communication (productive data)
- Parallel transfer of productive and TCP/IP data via a cable, even with considerable data traffic whilst ensuring the forwarding of productive data by reserving the transmission bandwidth.

International standard IEC 61158

The communication functions RT and IRT are standardized in the international standard IEC 61158.

4.2.2 Performance levels for real-time communication

Properties

PROFINET IO is a scalable real-time communication system based on the layer 2 protocol for Fast Ethernet. With the transmission procedure RT for time-critical process data and IRT for considerably precise as well as isochronous processes, this gives you two performance levels for real-time support.
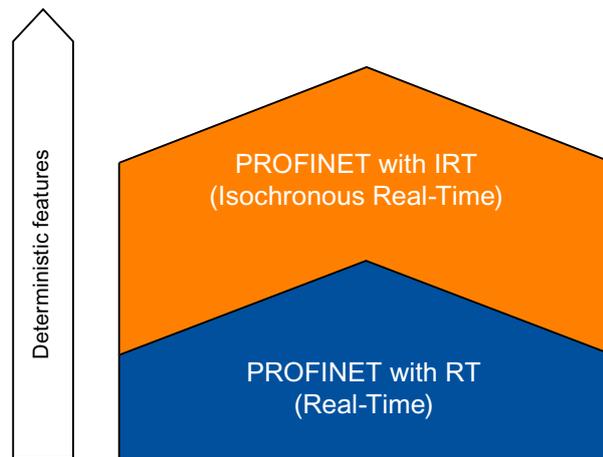
Figure 4-2   Performance of real-time communication

4.2.3 Real-time

PROFINET IO with real-time communication (RT) is the optimum solution for integrating I/O systems. This is a solution that also uses standard Ethernet in the devices and commercially available industrial switches as infrastructure components. A special hardware support is not required.

If you want to use the full PROFINET functionality, you must employ switches that support the PROFINET standard according to standard IEC 61158. In the integrated switches of PROFINET devices and PROFINET switches (e.g. the product family SCALANCE), PROFINET functions in accordance with the PROFINET standard are implemented and can be used without restriction for integration in the PROFINET IO system.

Real-time communication (RT)

PROFINET IO message frames have priority over standard message frames in accordance with IEEE802.1Q. This ensures the required determinism in the automation technology. The data is transferred via prioritized Ethernet message frames. You can realize update times from 250 µs with RT.

Switching mechanisms

Switches in SIMATIC meet the real-time requirements with two mechanisms on PROFINET: "Store and Forward" and "Cut through".

Store and forward

In the Store and Forward method, the switch stores the message frames completely and places them in a queue. If the switch supports the international standard IEEE 802.1Q, then the data is sorted according to its priority in the queue. The frames are then forwarded selectively to the specific port that can access the addressed node (Store and Forward).

Cut through

In the Cut Through process the entire data package is not stored temporarily in a buffer, it is passed directly onto the target port as soon as the target address and the target port have been determined.

The times required by the data package to pass through the switch are then minimal and independent of the message frame length. The data are only stored temporarily in accordance with the Store and Forward process as per priority when the section between the target segment and the port of the next switch is occupied.

Note

Interaction with multicast communication

If PROFINET RT and broadcast (BC) or multicast communication (MC) are operated at the same time on an Industrial Ethernet, PROFINET RT message frames can be delayed by long BC and / or MC message frames. These message frames are, among others, generated by the function blocks AG_SEND / AG_RECEIVE / TSEND / SRECV.

This could lead to station failures for IO devices in the RT operation, that is why you should increase the update time or the contact monitoring time in this case.

Note

Additional information on multicast communication

Additional information can be found on the Internet (http://support.automation.siemens.com/WW/view/en/29104898).

Real-time communication and PROFINET

In the case of industrial networks, the demands for a deterministic transmission in real-time are important. PROFINET meets these requirements. PROFINET is hence implemented as a deterministic real-time communication system as follows:

- Transmission of time-critical data takes place at guaranteed time intervals.

  To achieve this, PROFINET provides an optimized communication channel for real-time communication.

- Problem-free communication using other standard protocols is guaranteed within the same network.

4.2.4 Isochronous real-time

Isochronous real-time communication (IRT)

Synchronized transmission procedure for the cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth within the send clock is available for the IRT IO data. The reserved bandwidth ensures that the IRT data can be transmitted at reserved, synchronized intervals whilst remaining uninfluenced even by other greater network loads (e.g. TCP / IP communication or additional real time communication).

Advantages

PROFINET with IRT is synchronized communication in reserved time intervals. With IRT you have the option to be able to control time-critical applications like dynamic motion control via PROFINET. With IRT you use further advantages:

- Highly precise deterministics, even with considerable network load by means of standard communication

- Simple and flexible integration of PROFINET devices for real-time applications in existing company networks

- Reservation of transmission bandwidth and hence sufficient free resources for the transmission of data to real-time control

- Secured standard communication parallel to real-time communication via the same transmission medium

- You can continue to use standard components for your PROFINET IO system outside of the sync domain

- An increase in the update time calculated by STEP 7 dependent on the line depth is no longer necessary on account of the fixed reserved transmission bandwidth.

Properties of isochronous real-time

Implementation of the transmission method IRT in Ethernet controllers, the ERTEC ASICs (Enhanced Real-Time Ethernet Controller) allows update times of 250 μs and jitter accuracy of the send clock of less than 1 μs to be achieved.

IRT with high flexibility

The message frames are sent cyclically in a deterministic cycle (isochronous real-time). In addition, a fixed transmission bandwidth of the transmission resources will be reserved. A topological configuration of the system is not required. In principle, you can configure the topology if you, for example, wish to evaluate topological errors in the user program.

This procedure guarantees the advantage of the greatest possible flexibility in planning and expanding a system.

You can realize update times from 250 µs with IRT with high flexibility.

IRT with high performance

In addition to the reserved bandwidth, the telegrams from defined transmission paths are exchanged for the further optimization of data transfers. For this, the topological information from the configuration is used for planning the communication. Thus, transmission and reception points of every individual data telegram at every communication node are guaranteed. Through this, you can reach an optimal usage of the bandwidth and reach the best possible performance in the PROFINET IO system. Through IRT with reserved transmission bandwidth and topology configuration, you can realize the update times with the highest deterministic starting with 250 µs.

For IRT with high performance, the topology confirmation is a requirement. For the configuration of the topology, the topology editor is available. The topology editor can be called up from the context menu of the PROFINET IO system in the HW configuration.

With IRT with "high performance", isochronous applications are possible (see chapter: What is isochronous mode? (Page 132)). With IRT with "high flexibility", this function is not available.

Synchronization

The prerequisite for the IRT communication is a synchronization cycle for all PROFINET devices in a sync domain for distributing a mutual time basis. With this basic synchronization a synchronism of the transmission cycle of the PROFINET Devices within a sync domain is achieved. The sync master (IO controller) generates the mutual synchronization clock and specifies the time basis upon on which all other sync slaves (IO devices) are synchronized.

If the sync master fails, then IRT devices will are provided with RT-quality with the "high flexibility" option, IRT devices with the "high performance" option fail.

Reserving the transmission bandwidth

IRT is a transmission procedure whereby the PROFINET devices in a sync domain are synchronized with very high precision. Part of the communication cycle (send clock) is reserved for the IRT communication in which the deterministic message frames are sent. In doing so, for each send clock there is created a time range for IRT communication and a time range with RT and TCP/IP communication. The reservation of the transmission bandwidth is realized in terms of hardware technology by means of special Ethernet controllers (e.g. ERTEC).

In addition to this, the communication cycle belonging to a send clock is divided into three time ranges which are labeled with the colors orange, light green and dark green. In the following example, the send clock amounts to 1000 µs. If nothing else is stated, all figures are specified in µs.

Note

Unused bandwidth only with IRT with the "high flexibility" option

With IRT with the "high flexibility" option, there is an unused bandwidth that is exclusively reserved and cannot be used for other communication.

With IRT with the "high performance" option, due to the planned topology and the communication to the individual transmission paths calculated, there are no unused bandwidths.

---
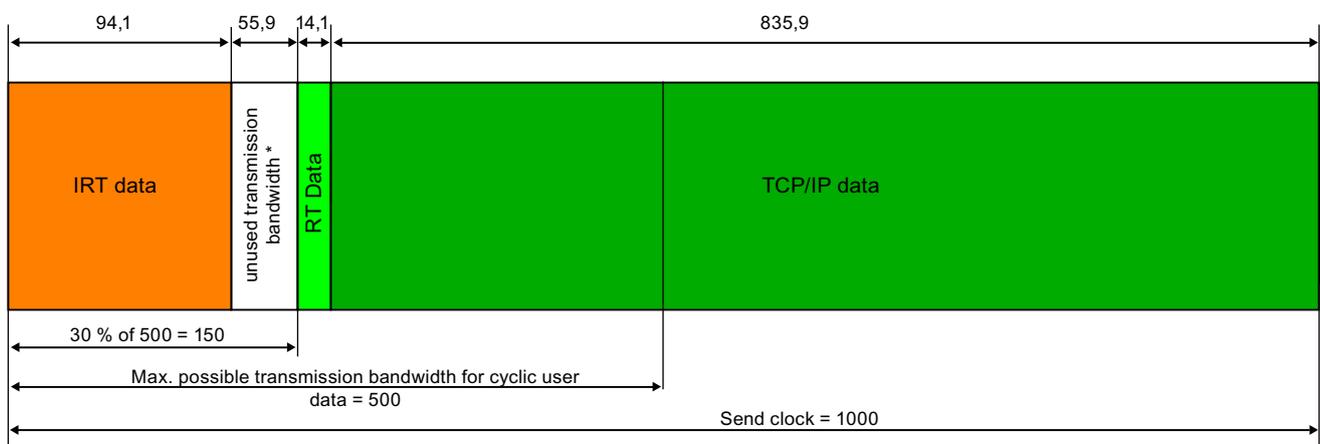
* only with IRT with the option "high flexibility"

Figure 4-3   Data message frames and their time intervals within a send clock

The example above is based on the following settings:

Table 4- 4   Example - communication traffic of a data message frame

Color	Setting / calculations	Data	Note
Not relevant	Send clock = 1 ms	Not relevant	Send clock settings: See chapter Basic terminology of communication (Page 58) in the send clock section and the following.
Not relevant	Max. possible transmission bandwidth for cyclic user data - here 500 µs	Not relevant	Resulting from the length of the send clock - at 1 ms the max. possible transmission bandwidth for cyclic user data = 500 µs, at 500 µs the max. possible transmission bandwidth for cyclic user data = 250 µs and at 250 µs the max. possible transmission bandwidth for cyclic user data = 100 µs
Orange + white (only with the option "high flexibility")	The high limit for IRT communication (reserved transmission bandwidth for IRT communication) is set as a proportion of the max. possible transmission bandwidth for cyclic user data in % (e.g. here 30 % of 500 µs = 150 µs)	IRT + unused bandwidth (only with the "high flexibility" option)	The reserved transmission bandwidth for IRT data (high limit for IRT data) must, on the one hand, be greater or equal to the actual used transmission bandwidth for the IRT communication, on the other hand, it must also comply with the following condition: The reserved transmission bandwidth for IRT communication (orange + white) and the used transmission bandwidth for RT communication (light green) together must not be greater than the maximum possible transmission bandwidth for cyclic user data.
Orange	For IRT used transmission bandwidth	IRT	Dependent on the number of synchronized PROFINET devices and the send clock of the PROFINET IO system. Within this time, only IRT data is transmitted.
White (only with the option "high flexibility")	Unused transmission bandwidth of the reserved transmission bandwidth for IRT communication that is not available for IRT communication and TCP/IP	Reserved for IRT communication but not used	The "orange" and "white" intervals together are the reserved area for IRT communication as a percentage of the possible transmission bandwidth for cyclic user data.
Light green	For RT used transmission bandwidth	RT	The cyclic RT message frames and the standard communication (TCP/IP etc.) are transmitted in the "light and dark green" time range. The Ethernet message frames are again prioritized according to "urgency" in levels from "Prio 1 (low)" to "Prio 7 (high)" IEEE 802.1Q. RT data in PROFINET IO is of priority 6.
Dark green	Transmission bandwidth for TCP/IP is send clock - reserved transmission bandwidth - transmission bandwidth for RT	TCP/IP	The cyclic RT message frames and the standard communication (TCP/IP etc.) are transmitted in the "light and dark green" time range. The Ethernet message frames are again prioritized according to "urgency" in levels from "Prio 1 (low)" to "Prio 7 (high)" IEEE 802.1Q. RT data in PROFINET IO is of priority 6.

Configuring IRT with STEP 7

- How you configure IRT in STEP 7 can be read in chapter Configuring the IRT communication of a PROFINET IO system (Page 202).

- How you can configure the topology of a PROFINET IO system with the topology editor can be read in chapter Configuring a topology (Page 190).

4.2.5 Comparison of RT and IRT

The most important differences between RT and IRT

Table 4- 5   Comparison between RT and IRT

Property	RT	IRT with high flexibility	IRT with high performance
Transmission method	Prioritizing the RT message frames through Ethernet priority (VLAN tag)	Reserving the transmission bandwidth by reserving a time range in which only IRT communication takes place and, for example, no TCP/IP frames are transmitted.	Path-based switching on the basis of a communication path plan; no transmission of TCP/IP frames in the time area with IRT communication.
Determinism	Variance of the duration of transmission by the mutual use of the transmission bandwidth with other protocols (e.g. TCP/IP)	Guaranteed transmission of the IRT message frames in the current cycle by the reserved transmission bandwidth.	Exact, planned transmission, transmission and reception times are guaranteed for all topologies.
Hardware support through special Ethernet controllers is required	Not required	Required	Required
Isochronous application	-	No	Yes (only for the integrated PN IO interface of the CPU)
Starting time of the isochronous application	-	-	The point in time for the reception of the data is planned exactly. Isochronous application can be started directly after this (similar to DP)

4.3 Option handling

4.3.1 Option handling

General procedure

Option handling enables you to set up the IO device for future expansions (options). Option handling means that you install, wire, configure, and program the planned maximum configuration for the IO device.

You can choose between three option handling variants, according to your requirements:

- Option handling *with* RESERVE modules
- Option handling *without* RESERVE modules
- Adding options

A combination of this procedure is permissible.

Option handling *with* RESERVE modules

The optional electronic modules are initially replaced with inexpensive RESERVE modules which are then later exchanged with the planned electronic modules.

This means that the IO device can be completely prewired ("master cabling") since the RESERVE module is not connected to the terminal module terminals and therefore not to the process.

The RESERVE modules for future expansions at the right-hand end of the IO-device do not have to be mounted. In this case, preparatory installation and wiring are possible but not a prerequisite.

Option handling *without* RESERVE modules

With this variant, the use of RESERVE modules is not necessary. The modules are mounted side-by-side without gaps. Preparatory mounting and wiring are not required for the optional electronic modules.

Note

Mark the modules in your installation with the slot numbers from your configuration.

Adding options

With this procedure, modules can be added to the end of the configuration. If the "add" option is not selected, reserve modules must not be inserted for this module. On the basis of the freely selectable slot number assignment, you can also start the adding of options from the "middle" of the configuration.

4.4 Device replacement without removable media / PD

4.4.1 What is device replacement without removable media / PD?

Definition

IO devices which support the PROFINET function "Device replacement without removable media / PG can be replaced without having inserted removable media
(e.g. Micro Memory Card) with saved devices names or without having to assign the device name to the PG.
The substituted IO device is given a device name by the IO controller and not by the removable media or the PD.

To do this, the IO controller and the neighboring PROFINET devices of the replaced IO device must support the PROFINET function "Device replacement without removable media / PD".

To assign the device name, the IO controller uses the configured topology and the neighborhood classifications established from the IO devices.

Requirements for the PROFINET functionality Device replacement without removable media / PD

If you want to use the PROFINET function Device replacement without removable media / PD, the following conditions must be fulfilled:

- The topology of the PROFINET IO system with the respective IO devices must be configured.

  By configuring the topology, the PROFINET IO system or the IO controller will make known the neighbor relationships of all the PROFINET devices located in the PROFINET IO system. From the neighbor relationships specified by the set topology and the actual neighbor relationships established by the real PROFINET devices, the IO controller can identify the replaced IO device without a name and assign to it the configured name and the IP address and then again list it in the user data traffic.

- The PROFINET function Device replacement without removable media / PD must be configured in STEP 7 for the IO controller the IO devices of which support this PROFINET function.

- The IO controller and the IO devices must support the PROFINET function Device replacement without removable media / PD.

- The PROFINET devices connected to the respective IO device must support the PROFINET Function Device replacement without removable media / PD.

- It must be possible to reset the replaced device to its factory settings prior to replacement.

Advantages

With the Device replacement without removable media / PD PROFINET function can profit from the following advantages:

- After replacing the IO device it automatically obtains its device name from the IO controller. You no longer have to assigned a device name with the PD or a removable medium (Micro Memory Card).

- You can save on the storage medium for the replaced IO device.

- You can save on the time required to load the device data on the memory card and in the IO device.

- Simple device name allocation with series machines that have the same configuration and set topology. It is no longer necessary to assign device names via a removable medium / PD.

4.4.2 Engineering

Procedure in HW Config

To configure the PROFINET function "Device replacement without removable media / PD" for the PROFINET IO system, proceed as follows:

1. Double click on the PROFINET interface of the respective IO controller that is to support the PROFINET function "Device replacement without removable media / PD".
   The "Properties" dialog box for this PROFINET interface opens.

2. Select the "Supporting device replacement without removable media" check box.

3. Save the setting of the interface by clicking "OK".

4. Save and compile the settings in HW Config.

5. Download the configuration to the IO controller.

Result

All IO devices in the PROFINET IO system which have been topologically configured and reset to factory settings and still have no valid device name (no Micro Memory Card inserted or Micro Memory Card without a valid device name inserted) are given their device names by the IO controller. This way, without any explicit name allocation by the user, it can be listed by the IO controller in the user data traffic.

Note

Prerequisite for the automatic allocation of the device name

All IO devices which automatically obtain their device names from their IO controller must be in the "reset to factory" state and the set topology must comply with the actual topology.

Note

Device replacement with devices that already have a valid device name

If the IO device has a removable medium (Micro Memory Card, C PLUG) with a valid device name or if, prior to the replacement, it has been configured for a prioritized startup, then this device will keep its already valid and assigned device name.

4.5 Prioritized startup

4.5.1 What is prioritized startup?

Definition

Prioritized startup refers to the PROFINET function for accelerating the startup of IO devices (distributed I/O) in a PROFINET IO system with RT and IRT communication. It shortens the time that the respective configured IO devices (distributed I/O) require in order to reach the cyclic user data exchange in the following cases:

- After the supply voltage has returned

- After a station has returned

- After IO devices have been activated (distributed I/O)

Advantages

The PROFINET function "Prioritized startup" enables PROFINET IO applications in which machine parts or tools and their IO devices (distributed I/O) have permanently replaced (refer also to chapter Docking station - changing IO devices during operation (distributed I/O) (Page 80)). Waiting times of several seconds between the scheduled processes of the restart are reduced to a minimum by this optimization. This accelerates the production process with removable IO devices (distributed I/O) e.g. in tool-changer applications, and enables a greater throughput in production.

The PROFINET function "Prioritized startup" offers a considerable increase in performance also for applications where a quick startup time of the IO devices (distributed I/O) after "power on" or after station failure / station return is required, or when activating IO devices (distributed I/O).

Properties

You can realize the following properties with the PROFINET function "Prioritized startup":

- Communication readiness of the IO devices (distributed I/O) up to minimum 500 ms.

- You can use the prioritized startup for IO devices (distributed I/O) both with RT as well as with IRT communication.

Startup times

The length of the startup time of an IO device (distributed I/O) with the PROFINET function "Prioritized startup" is dependent on the following points:

- IO devices used (distributed I/O)
- IO structure of the IO devices (distributed I/O)
- Used modules of the IO devices (distributed I/O)
- Used IO controller
- Used switch
- Port setting
- Cabling
- Configured RT class from the IO device in STEP 7

Note

Startup time and RT class of the IO device

For the accelerated startup, an IO device with IRT configuration and "high performance" option needs longer than an IO device with RT communication.

The longer startup with IRT with the "high performance" option results from the necessity to synchronize the IO device before the communication can be setup!

Note

Prioritized startup after a startup for the first time

A prioritzed startup of the IO devices (distributed I/O) is always available to you after the first configuration of this IO device (distributed I/O) in the very first startup of the PROFINET IO system. Even in the case of spare parts or a reset to factory settings, the first startup is a standard startup for the respective configured IO devices (distributed I/O).

Note

In the following situations, despite prioritized startup, there may be startup times of up to 8 s:

- An IO/device is disconnected and reconnected within 8 seconds.
- On a docking point, you can dock multiple physical IO devices as an IO device with a certain device name and a certain IP configuration (for example, docking point for automatic transport system).

If you wish to achieve a shortest possible startup time of 500 ms, you must carry out the following measures:

● Configure the PROFINET function in STEP 7 (chapter Engineering (Page 77))

● Port setting on the IO device (distributed I/O) (chapter Settings for minimum startup times (Page 78))

● Wiring depending on the interconnected PROFINET device
(chapter Settings for minimum startup times (Page 78))

● Measures in the user program (chapter Docking station - changing IO devices during operation (distributed I/O) (Page 80))

The following two chapters explain how to correctly implement the specified measures.

4.5.2   Engineering

Conditions for configuring the prioritized startup

You can enable the PROFINET function "Prioritized startup" for the IO devices (distributed I/O) only in the following cases:

● The used IO controller can prioritize selected IO devices (distributed I/O) during startup.

● The used IO device (distributed I/O) supports the prioritization.

Note

Prioritized startup

In the case of an accelerated startup (prioritized startup), you must observe special conditions when setting up the PROFINET interface and when wiring if you wish to achieve the shortest possible startup times.

Procedure in HW Config

1. Open the "Properties" dialog box of the respective PROFINET device interface (IO device (distributed I/O).

2. In the "General" tab, enable the "Prioritized startup" check box.

3. To save the settings and close the dialog, click on "OK".

4. Save and compile the settings.

5. Download the configuration to the IO controller.

Note

Number of IO devices (distributed I/O) with prioritized startup

Within a PROFINET IO system you can allow only one of the maximum number of IO devices (distributed I/O) that are dependent on the used IO controller with the PROFINET function "Prioritized startup" to run.

4.5.3   Settings for minimum startup times

Introduction

If you are using fixed port settings and twist pair cables, you can further optimize the startup time.

To do this, in the "Properties" dialog box of the STEP 7 port, carry out the settings as described in the following section.

Procedure in STEP 7

To perform a fixed port setting, proceed as follows:

1. Open the respective project in STEP 7
2. Select the IO device (distributed I/O) for which you want to carry out a fixed port setting.
3. Double click on the respective port. This opens the "Properties" dialog box of the respective port.
4. Select the "Options" tab.
5. In the drop-down list "Transfer medium / Duplex", set the value to "TP / ITP" with 100 Mbps full duplex.
6. Select the "Disable autonegotiation" check box.
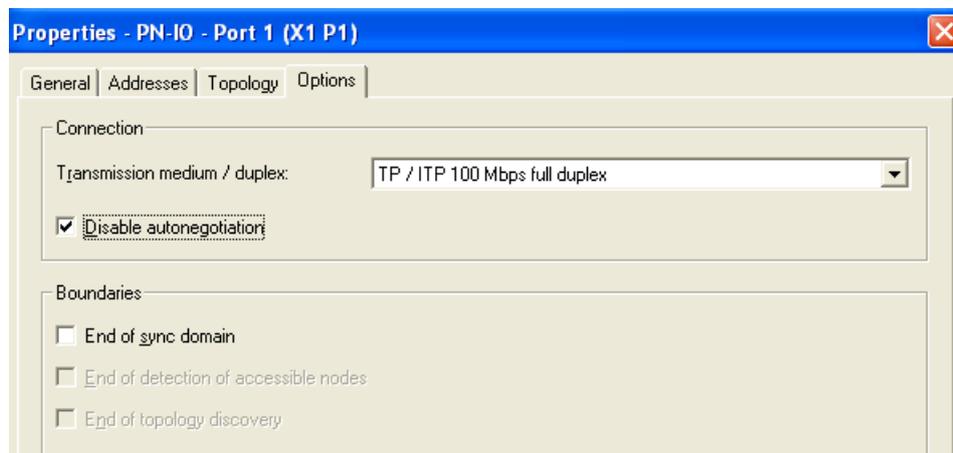
7. Save the settings of the port and end the dialog with "OK".
8. Repeat steps 1 to 7 for the device or the device port with which the IO device is connected.

Result

You have carried out the following settings for the respective port:

- Fixed transmission rate
- The function autonegotiation including autocrossing has been disabled

The time for negotiating the transmission rate during startup has been saved.

If you have disabled autonegotiation, you must observe the wiring rules.

Wiring rules for disabled autonegotiation

PROFINET devices have the following two types of ports:

Type of port	PROFINET devices	Note
Switch port with crossed pin assignment	For IO devices: Port 2 For S7 CPUs with 2 ports: Ports 1 and 2	Crossed pin assignment means that the pin assignment for the ports for sending and receiving between the respective PROFINET devices is exchanged internally.
End device port with uncrossed pin assignment	For IO devices: Port 1 For S7 CPUs with one port: Port 1	-

Validity of the wiring rules

The cabling rules described in the following paragraph apply exclusively for the case that you have specified a fixed port setting in STEP 7.

Rules for cabling

You can connect several IO devices (distributed I/O) with one cable type (patch cable) in line. In addition to this you can connect port 2 of the IO device (distributed I/O) with port 1 of the next IO device (distributed I/O). The following graphic gives an example with two IO devices (distributed I/O).
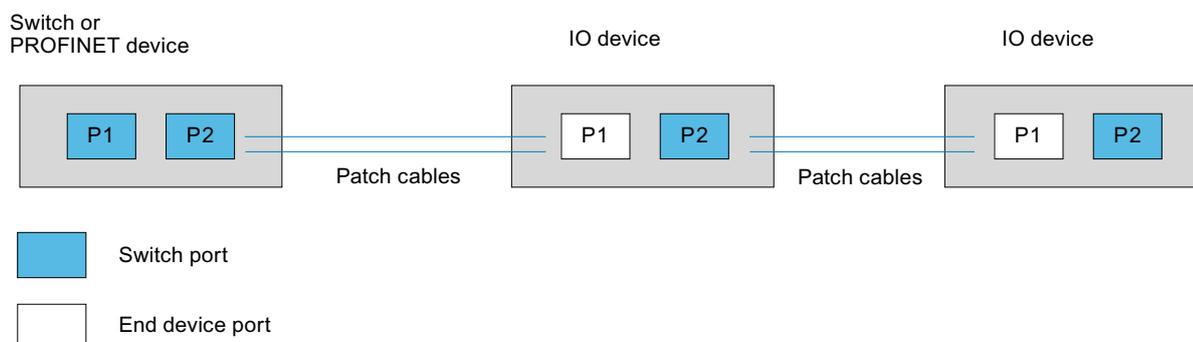
Figure 4-4   Example of cabling for IO devices (distributed I/O) with port setting "TP / ITP with 100 Mbps full duplex" and deactivated autonegotiation.

See also

RJ45 and M12 cable pin assignment (Page 265)

4.6 Docking station - changing IO devices during operation (distributed I/O)

Using "Changing IO devices during operation (changing partner ports)" in a docking station

The following figure shows an automation cell with a docking system.
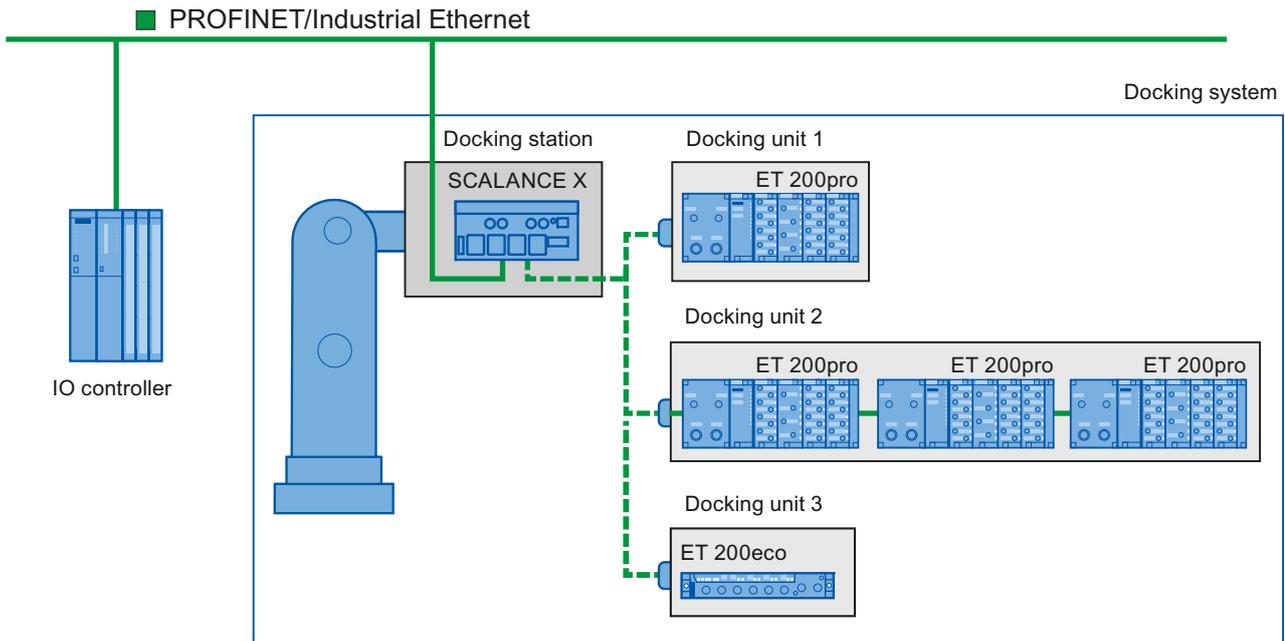
Figure 4-5   Alternating IO devices (partner ports) in a docking system

Applicative conditions

The following points should be observed when realizing a docking system with changing IO devices during operation:

- The IO devices of all docking units must be deactivated as default in the configuration.

- At any time only one docking unit may be active, i.e. only the IO devices of one docking unit can be activated. All IO devices of other docking units must be deactivated or become deactivated before the IO devices of a docking unit can be activated. This takes place using the system function SFC 12.

- A physical connection to this docking unit and its IO devices must be created in order to activate a docking unit. The IO devices are then switched on (power on). At the same time, all the IO devices of this docking unit must be activated in the user program with SFC 12.

- After the message "IO device activated" you can access the IO device by using the command "Direct I/O access".

- Call the system function block SFC 12 to activate and deactivate the IO device as close as possible to the start of the OB 1 cycle.

Area of application for changing IO devices during operation

You can use the PROFINET function "Changing IO devices during operation (changing partner ports)", e.g. for the tool change for robots. Typical tools are, for example:

- Welding guns

- holding tools for production parts.

Note

Number of IO devices changing during operation ("changing partner ports") - number of docking units

If you wish to achieve the shortest possible tool-change times, you must observe the following points that are dependent on the CPU or the CP that is being used:

- Only those IO devices that have been configured with the PROFINET function "Prioritized startup" can run in an optimized fashion. The number of IO devices with configuration for this PROFINET function is restricted.

- Only a specific number of IO devices can be enabled at the same time (dependent on the available SFC 12 resources) so then a docking unit should include nothing more than the respective number of IO devices. If more IO devices are operated in a docking unit, the IO devices must be enabled one after the other, which takes correspondingly longer.

Example: An S7 CPU 319-3 PN/DP can operate a maximum of 32 IO devices with prioritized startup and simultaneously 8 IO devices per SFC 12.

Therefore, for a scheduled optimum use, a docking unit should include no more than 8 IO devices and no more than 32 IO devices should be used in all the changing docking units.

Please note the information in chapter Settings for minimum startup times (Page 78).

Requirements for interconnecting partner ports that change during operation

You can interconnect IO devices with partner ports that change during operation in the following cases:

- The changing IO device (docking unit) does not have any IRT communication configured with the "high performance" option.

- The PROFINET interface is connected with the Ethernet subnet

- The PROFINET devices support topological configuration

- The IO controller, the changing IO devices (docking unit) and the switch (docking station) on which the changing IO devices are to be operated, must support this feature.

- The docking unit must be connected with a switch that supports the PROFINET function "prioritized startup" (e.g. from the SCALANCE X200IRT family).

Procedure in HW Config

1. Open the "Properties" dialog box by double-clicking the port of the IO device on which the changing IO devices (changing partner ports) are to be operated.

2. From the drop-down list "Partner port" in the "Topology" tab, select the value "Changing partner port".

3. Establish the partner ports that change during operation by first clicking "Add". A dialog opens that includes all the already configured and not yet topologically interconnected IO devices with their available ports.

4. From the drop-down list, select all the ports that can be connected during operation with this port. Click on the "OK" button.

5. The selected partner ports are transferred to the "Properties" dialog box

6. Save the settings of the port and end the dialog with "OK".

Result

You have interconnected the respective port with a port of one (or more) changing IO devices. All the configured partner ports are listed in the area "Changing partner port" under the "Properties" dialog box of the "Topology" tab of the port. The connections with the individual changing partner ports during operation are shown in the topology editor by a green, dashed line.

Interconnecting several IO devices with "Changing IO devices ("changing partner port") during operation

You can configure IO devices on a docking unit which are interconnected in line with "Changing IO devices (partner ports) during operation" with the port of the changing IO devices as usual. The following figure shows a changing IO device (docking unit 2-1) with twin in-line cabled IO devices (docking unit 2-2/-3)

Deleting the partner port in HW configuration

In the "Properties" dialog box, remove the interconnection of the partner port that changes during operation as follows:

1. Select the changing partner port.

2. Click "Delete".

3. Save the settings and end the dialog with "OK".

Configuring and showing changing IO devices ("changing partner port") during operation in the topology editor
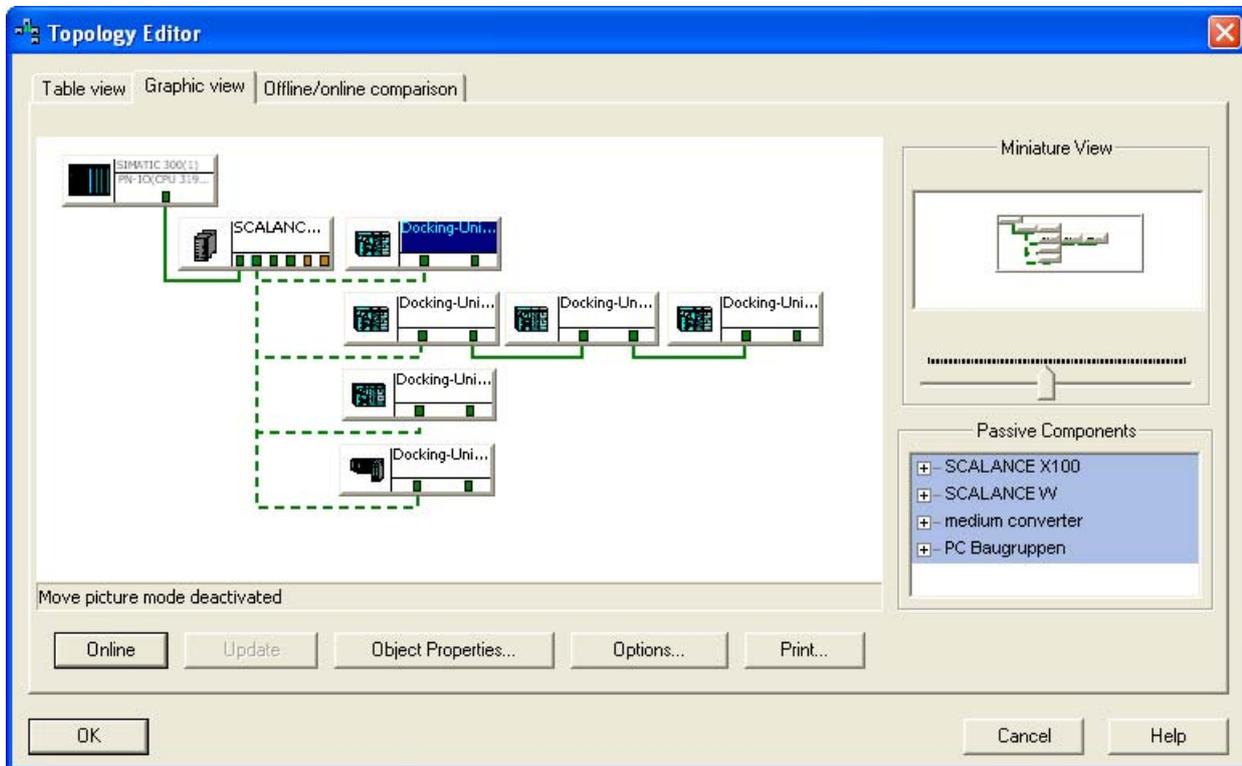
Figure 4-6   Changing IO devices (partner ports) during operation in the topology editor

The connections of ports that are configured as changing IO devices ("changing partner port") during operation are shown as a dashed line in the color of the respective medium.

Color-coded identification of the medium

The color of the connections has the following meaning in the offline mode of the graphic view:

Color	Property	Object
Dark green	Copper media type	Port, interconnection
Dashed, dark green	Copper media type	Partner port, interconnection
Ochre yellow	Fiber-optic cables media type	Port, interconnection

To configure the changing partner port in the graphic view, execute the following steps:

1. Open the topology editor of the respective PROFINET IO system in its shortcut menu with the menu command **PROFINET IO topology** and then switch to the graphic view.

2. To configure the port to which changing IO devices are to be configured, open its "Properties" dialog box, by double-clicking the port.

3. From the drop-down list, select the entry "changing partner port".

4. Establish the partner ports that change during operation by first of all clicking "Add". A dialog opens that includes all the already configured and not yet topologically interconnected IO devices with their available ports.

5. From the drop-down list, select all the ports that can be connected during operation with this port. Click on the "OK" button. Alternatively, you can connect the two ports using drag and drop in the "Graphic view" tab.

6. Save the settings and end the dialog with "OK".

Result

You have interconnected the respective port with one or more ports of a changing IO device. The interconnections of the changing partner ports will be shown in dashed lines.

Restriction in the interconnection

The interconnection with a partner port is not possible in the following cases:

- The partner port doesn´t have a suitable type of cable. In this case, a media convertor from the catalog must be inserted.

- The partner port is blocked (deactivated).

- The two ports that are to be interconnected belong to the same interface
  (it is possible only to interconnect the ports from different interfaces in a station).

- You are trying to create a ring connection with a module that is not redundant-capable.

- The two ports that are to be interconnected belong to different Ethernet subnets.

- The port of one PROFINET interface of an IO controller cannot be directly configured with the function Changing IO devices ("changing partner port") during operation

---

Note

Non-realizable interconnection

If you try to generate an interconnection that is not possible, when removing the connection, information is shown in the tool tips above the partner port and the mouse pointer takes the form of a no-stopping sign. If you then try to generate the interconnection, a warning dialog is shown that you must then confirm.
The interconnection is not executed.

Deleting interconnections

To delete an interconnection, select the interconnection. Delete the interconnection via the "Disconnect port interconnection" shortcut menu or with the "Remove" key.

4.7 Shared Device

4.7.1 Shared Device functionality

Shared Device functionality

Numerous IO controllers are often used in larger or widely distributed systems. In this situation, it is possible that sensors in close geographical proximity to each other need to send data to different IO controllers. In the past this had to be solved through several IO devices that were assigned to different IO controllers. The shared device functionality allows the submodules of an IO device to be divided up among different IO controllers saving one or more interface modules.

① PROFINET
② logical assignment
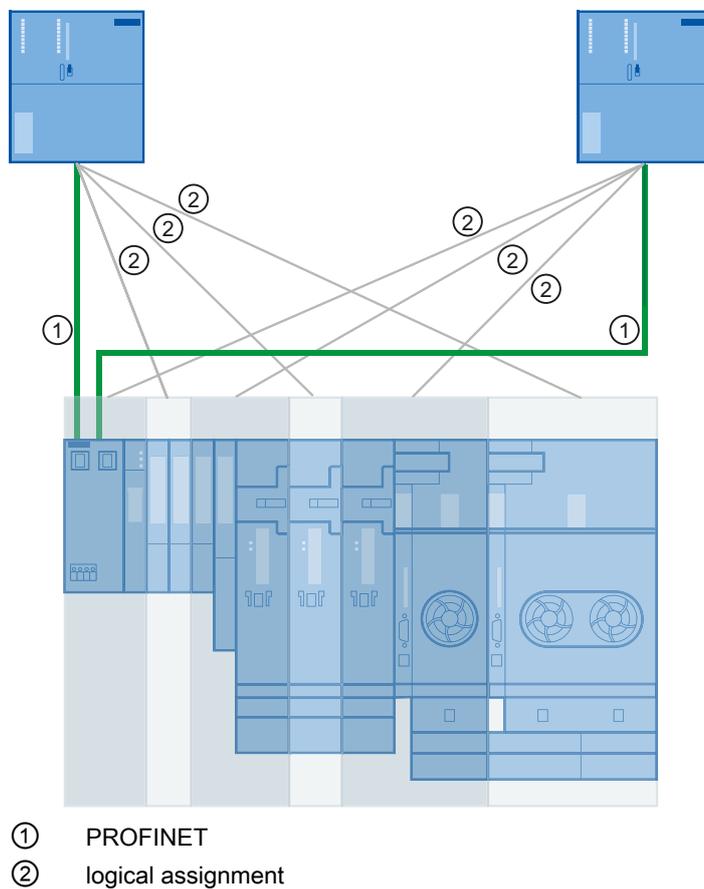
Figure 4-7   Shared device principle

Other application cases

In a system, safety technology is required for some component parts. That is why a F-CPU is used in addition to the standard CPU, which provides for the secure switching off of the critical system parts.

With the shared device function, it is possible to setup an IO device from the F and standard modules and to assign the individual modules corresponding to the F-CPU and the standard CPU.

General procedure

Access to the submodules of the shared device is then divided up among the individual IO controllers. Each submodule of the shared device can be assigned exclusively to an IO controller. The assignment of the individual submodules is made in HW Config.

Representation in HW Config

A shared device is shown more than once in HW Config. If, for example, a shared device is used by two IO controllers, the same device appears in two different stations in HW Config.

Modules that consist of exactly one sub module are displayed in the user view as a module.

Basics of configuration

- E/A addresses can be assigned to the submodules belonging to the controller as usual.

- A shared device must have the same IP parameters and the same device name in each station. During configuration, two situations must be distinguished:

  – Shared device in the same project: STEP 7 allows the user to execute important consistency inspection functions. The checking of the correct assignment of the IP parameters and the monitoring of the correct access by the IO controller to the individual submodules is performed by STEP 7.

  – Shared device in different projects: The stations with the IO controllers that use the shared device are created in different projects. In each project, care must be taken that the shared device is configured identically in each station. Only one IO controller may ever have full access to a submodule (see below). The IP parameters and device names must be identical. Inconsistencies in the configuration will cause failure of the shared device.

Types of access

Each sub module can be assigned a maximum of one IO controller.
Types of access and their significance:

- Full access. The IO controller has full access to the sub module and its logical address.
  Rights of the IO controller:

  – Read and write access to input data, output data and data records

  – Assignment of parameters for the submodule

  – Reception of interrupts from the submodule

- no access: The IO controller has no access to the sub module (and the sub module does
  not have a logical address). For the IO controller, this means in particular that:

  – There is no data exchange with the submodule.

  – No interrupts can be received from the submodule.

  – Submodules cannot be assigned parameters.

4.7.2   Engineering

4.7.2.1   Shared Device in the same STEP 7 project

Introduction

In the following example, the simplest configuration of a shared device is described:
Two IO controllers share the submodules of an IO device. The two IO controllers are in the
same STEP 7 project with the advantage that the consistency check is made automatically.

Procedure

To be able to use the shared device function, you need to take certain configuration steps
both in the SIMATIC Manager and in HW Config.

Preparatory steps

1. Create a project called "Shared device project" in the SIMATIC Manager.

2. Insert two stations (SIMATIC 300).

3. Open the stations in HW Config and configure a CPU with a PROFINET interface
   (in the case described here CPU 319-3 PN/DP).

4. Set the parameters for the PROFINET interfaces of the stations you have just created.

5. "Save and translate" the individual stations.

Creating the shared device

1. Open one of the stations you created in HW Config.

2. Configure a PROFINET IO device ET 200S (IM151-3PN) with several submodules as shown in the screenshot.
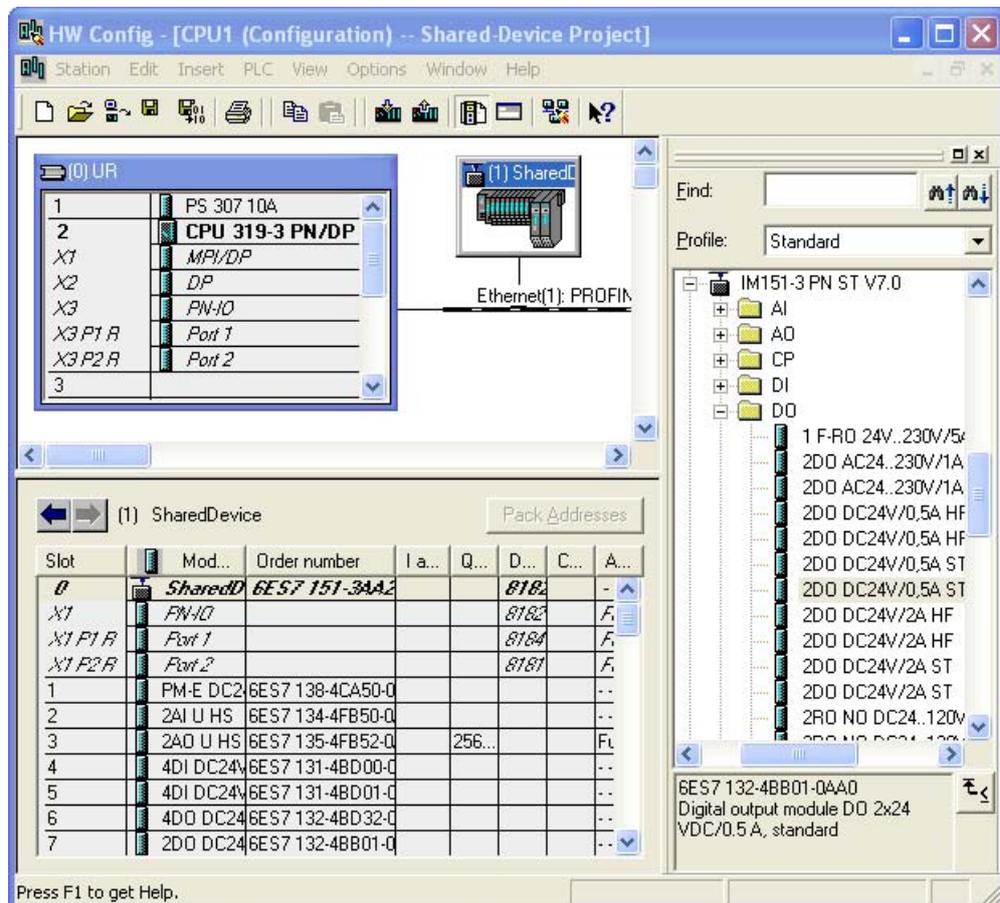
Figure 4-8   Shared device, creating distributed IO system

3. Copy the distributed IO device you have just created using the context menu (right mouse button).

4. Save the hardware configuration and close the configured station.

5. Open the other station you created earlier in HW Config.

6. In order to add the IO device as a shared device, right click on the PROFINET IO system. Select the "Paste Shared" command in the shortcut menu.

7. Save the hardware configuration and close the configured station.

You have successfully created the shared device, now set the assignments of the submodules to the configured stations.

Assigning submodules

The submodules must be assigned separately for each station. Remember that changes to a station will also impact the other station(s)! A submodule can only ever be assigned to one station!

1. Open the properties dialogue box of the PROFINET IO device in the first station.

2. Go to the "Access" tab.
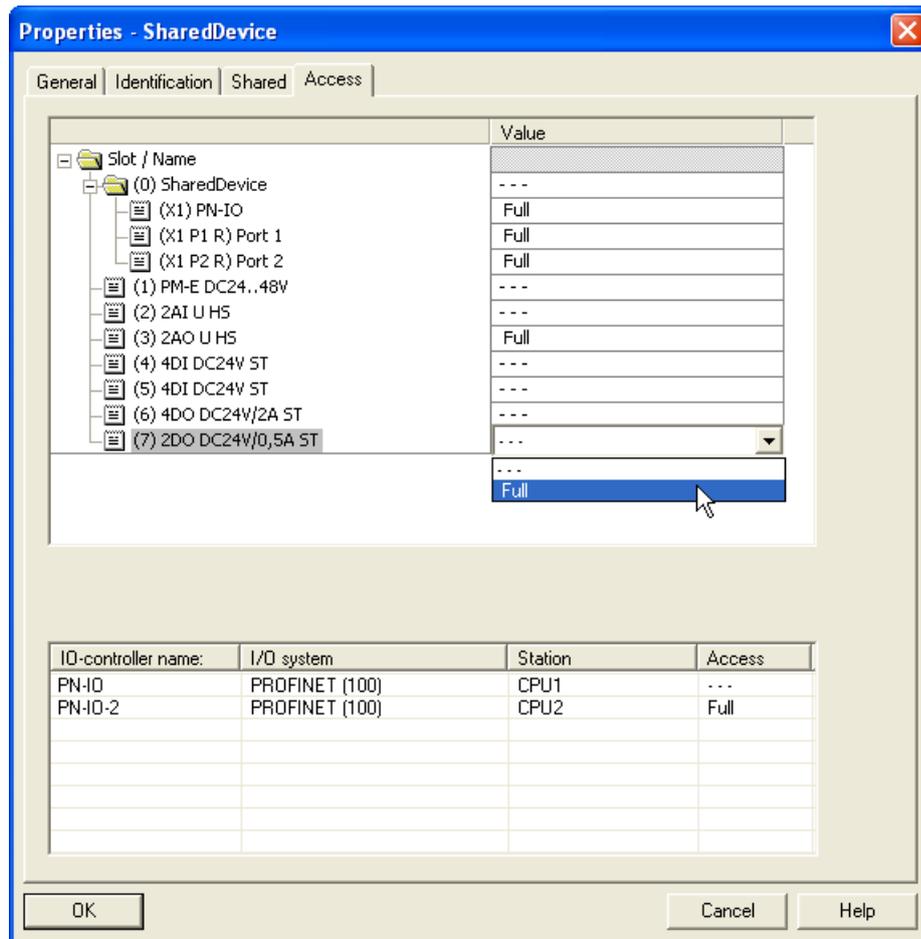
Figure 4-9   "Access" tab

3. Configure the access to the individual submodules. Select the type of access from the drop-down list in the "Value" column. You can select from the following:

   – No access to the submodule: "- - -"

   – Full access to the submodule: "full"

   Note that the setting "Full" automatically leads to the setting "- - -" in the other station(s).

4. Save and compile the station and close the project.

5. Repeat steps 1. to 4. for the second station.

6. Then download the configuration to the stations.

Shared device in the user program

The shared device has no special role in the user program. The submodules assigned in the station are addressed as usual through your addresses, the other submodules do not receive addresses.

4.7.2.2 Shared Device in different STEP 7 projects

Introduction

The following example describes the configuration of a shared device in different STEP 7 projects. In the example, two IO controllers share the submodules of an IO device.

Procedure

To be able to use the shared device function, you need to take certain configuration steps both in the SIMATIC Manager and in HW Config.

Preparatory steps

1. Create a project called "Shared device 1" in the SIMATIC Manager.

2. Insert a station (SIMATIC 300) with the name "CPU1".

3. Open the station in HW Config and configure a CPU with a PROFINET interface (in the case described here CPU 319-3 PN/DP).

4. Set the parameters for the PROFINET interface of the station you have just created.

5. "Save and compile" the station and close the project.

6. Create a second project called "Shared device 2" in the SIMATIC Manager.

7. Insert a station (SIMATIC 300) with the name "CPU2".

8. Repeat steps 3 to 5.

Creating the shared device

1. Open the project "Shared device 1".

2. Open the station "CPU1" in HW Config.

3. Configure a PROFINET IO device ET 200S (IM151-3PN) with several submodules as shown in the screenshot.
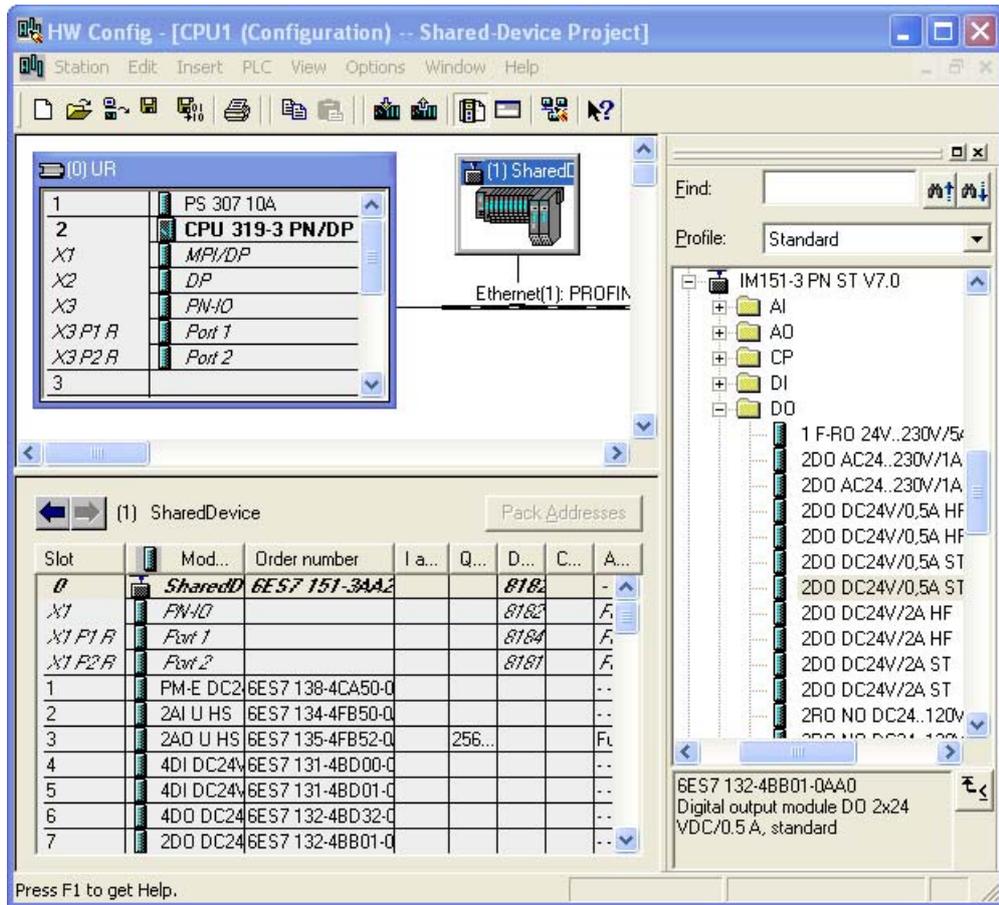
Figure 4-10   Shared device, creating distributed IO system

4. Note down the precise configuration of the ET 200S you have just created.

5. Save and compile the hardware configuration and close HW Config and the project.

6. Open the project you created earlier "Shared device 2".

7. Open the station "CPU2" in HW Config.

8. Configure the PROFINET IO device ET 200S with exactly the same configuration as the ET 200S in the "shared device 1" project in the station "CPU1" (notes from step 4).

9. Save and compile the hardware configuration and close HW Config and the project.

You have successfully created the shared device, now set the assignments of the submodules to the configured stations.

Note

Send clock

Make sure that for a project-wide usage of the shared device, the send clock for the shared device is set identically in the projects. The shared device can otherwise not be accepted by the IO controller.

Assigning submodules

The submodules must be assigned separately for each station in both projects.
Note that a submodule can only ever be assigned to one station!

1. Open the "CPU1" station of the "Shared device 1" project in HW Config.

2. Open the Properties dialog of the PROFINET IO device.

3. Go to the "Access" tab.

4. Configure the access to the individual submodules. Select the type of access from the drop-down list in the "Value" column. You can select from the following:

   – No access to the submodule: "- - -"

   – Full access to the submodule: "full"

5. Save and compile the hardware configuration and close HW Config and the project.

6. Open the "CPU2" station of the "Shared device 2" project in HW Config.

7. Repeat steps 2. to 5.

NOTICE

Access rules

A submodule can only ever be assigned to one IO controller. This means, for example, that the submodule in slot 4 can only be assigned to "CPU1" with the setting "Full access"; in "CPU2", the setting "- - -" ("No access") must therefore be selected for the submodule in slot 4.

Bandwidth reservation

When configuring shared devices in different projects, STEP 7 requires information on the other locations of use of the shared device to be able to calculate the bandwidth. Make the following settings in **both** projects:

1. Open the "Shared device 1" / "Shared device 2" project.

2. Open the station "CPU1" / "CPU2" in HW Config.

3. Open the Properties dialog of the PROFINET IO interface and go to the "Shared Device" tab

4. Make the following settings:

   – If the IO controller has full access to the interface module of the IO device:
     The number of **external** controllers that have access to the IO device.

   – If the IO controller has no access to the interface of the IO device:
     The send clock of the IO controller with full access.

5. Save and compile the configuration.

6. Then download the configuration to the stations.

Note

Changing projects

Remember that changes to a shared device (for example, on the interface or port) must always be executed in all projects in which the shared device is used. The projects must then be compiled and loaded.

Shared device in the user program

The shared device has no special role in the user program. The submodules assigned in the station are addressed as usual through your addresses, the other submodules do not receive addresses.

4.7.3 Boundary conditions

Make sure of the following boundary conditions when using shared devices.

Send clock

The shared device function can be used with even send clocks
(see send clock section in chapter Basic terminology of communication (Page 58)).

Isochronous mode

A shared device cannot be operated in an isochronous manner.

IRT

A shared device can only be used in connection with IRT with the IRT option
"high performance".

Quantity structure

The maximum E/A quality structure of an IO device that is used as a shared device may
not be exceeded - independent of the module or submodule assignment to the individual
IO controllers.

Note

If the sync master of a shared device (which is operated with IRT with "high performance")
fails, then it may lead to the shared device shortly failing for other IO controllers accessing it.

4.8 I-device

4.8.1 Overview

4.8.1.1 I-Device Functionality

I-Device Functionality

The "I-device" functionality (intelligent IO device) of a CPU allows data to be exchanged with an IO controller and therefore to use the CPU, for example, as an intelligent preprocessing unit of subprocesses. The I-device is linked as an IO device to a "higher-level" IO controller.

The preprocessing is handled by the user program on the CPU. The process values acquired in the central or distributed (PROFINET IO or PROFIBUS DP) I/O are preprocessed by the user program and made available via a PROFINET IO device interface to the CPU or the CP of a higher-level station.
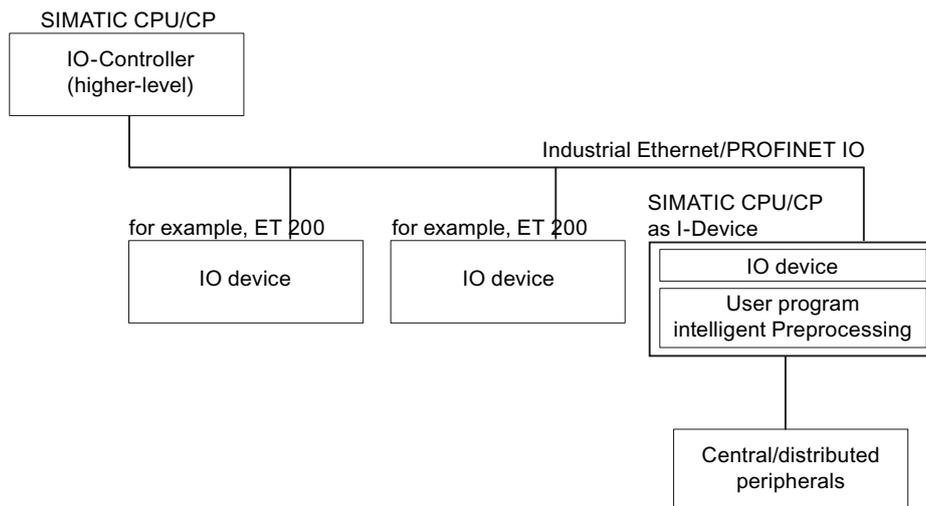
"I-device" naming conventions

In the remainder of this description, a CPU or a CP with the I-device functionality is simply called an "I-device".

4.8.1.2 Properties and Advantages of the I-Device

Fields of application

Areas of application of the I-device:

- Distributed processing

  A complex automation task can be divided into smaller units/subprocesses.
  This makes the process easier to handle because the subtasks are simpler.

- Separating subprocesses

  Complicated, widely distributed and extensive processes can be subdivided into several subprocesses with manageable interfaces by using I-devices. These subprocesses in turn are stored in the individual STEP 7 projects that are merged to form an overall project.

- Know-how protection

  System parts can only be delivered with a GSD file for the interface description of the I-device instead of with a STEP-7 project. The know-how of the user program must no longer be published.

Properties

Properties of the I-device:

- Separating STEP 7 projects

  Creators and users of an I-device can have completely separated STEP 7 projects.
  The interface between the STEP 7 projects is the GSD file. This allows a link to standard IO controllers via a standardized interface.

- Real-time communication

  The I-device is made available for a deterministic PROFINET IO system via a PROFINET IO interface and therefore supports real-time communication and isochronous real time.

Advantages

The I-device has the following advantages:

- Simple linking of IO controllers without additional software tools

- Real-time communication between SIMATIC CPUs and with standard IO controllers

- By distributing the computing power on several I-devices, the required computing power of the individual CPUs and, of course, of the IO controller can be reduced

- Lower communications load by processing process data locally.

- Manageable processing of subtasks in separate STEP 7 projects

4.8.1.3   Characteristics of an I-Device

Principle

An I-device is included in an IO system like a standard IO device.

I-device without subordinate PROFINET IO system

The I-device does not have its own distributed I/O (no IO controller). The configuration and parameter assignment of the I-devices in the role of an IO device is the same as for a distributed I/O system (for example ET 200).

SIMATIC CPU/CP
as I-Device

IO-Controller
user program

Industrial Ethernet/PROFINET IO

for example, ET 200   for example, ET 200   SIMATIC CPU/CP
as I-Device

IO device   IO device   IO device

User program
intelligent Preprocessing
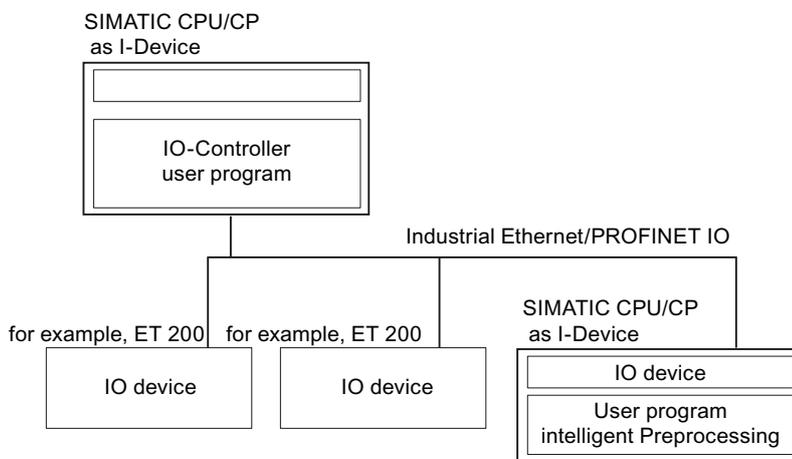
I-device with subordinate PROFINET IO system

Depending on the configuration, an I-device can also be an IO controller on a PROFINET interface in addition to having the role of IO device.

This means that the I-device can be part of a higher-level IO system via its PROFINET interface and as an IO controller can support its own lower-level IO system.

The lower-level IO system can, in turn, contain I-devices (see figure below). This makes hierarchically structured IO systems possible.
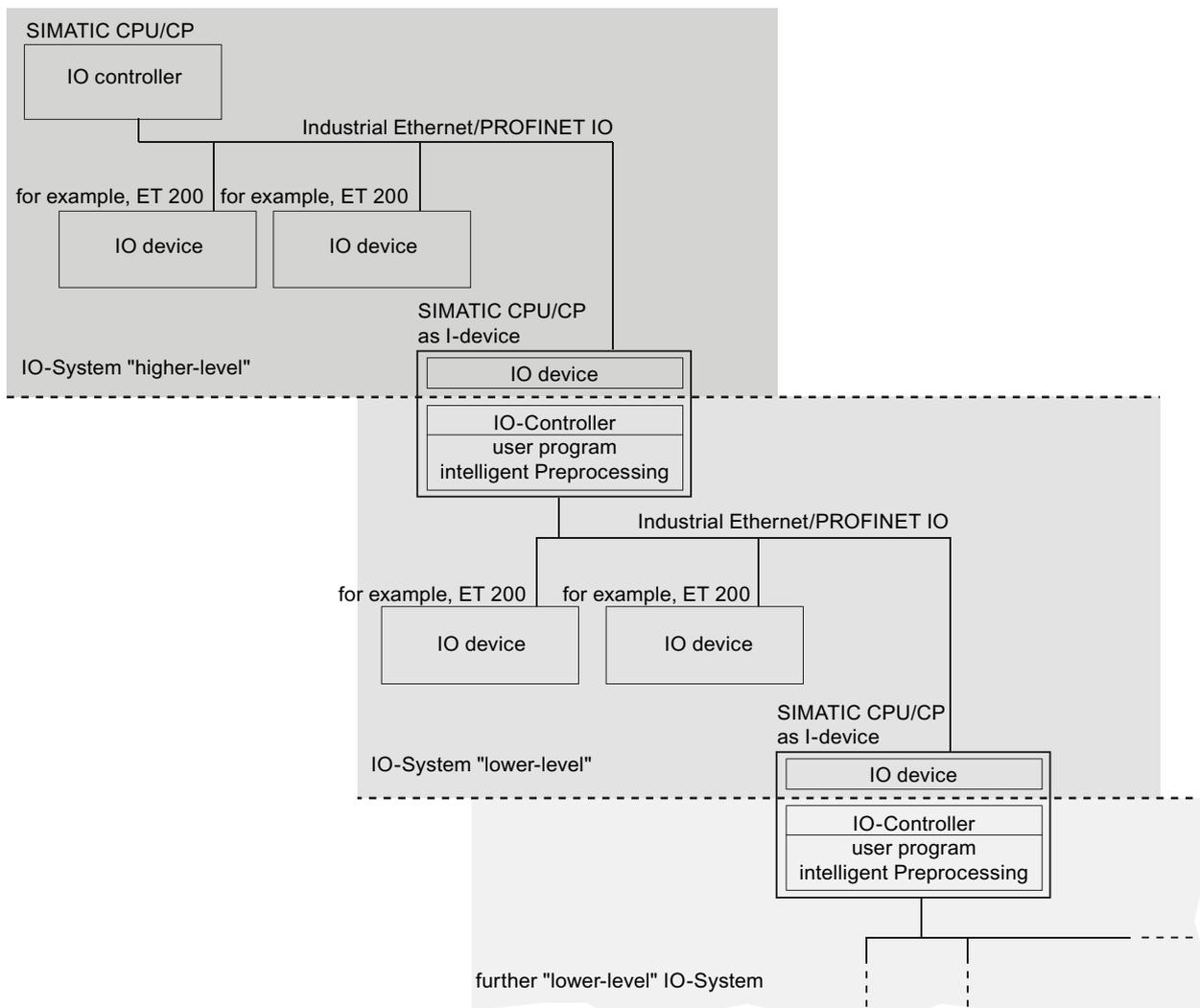
Figure 4-11   IO-system with I-device and lower-level IO-system

I-device as shared device

An I-device can also be used by more than one IO controller at the same time as a shared device.

Example - the I-device as IO device and IO controller

The I-device as IO device and IO controller is explained based on the example of a print process. The I-device controls a unit (a subprocess). One unit is used, for example, to insert additional sheets such as flyers or brochures in a package of printed material.
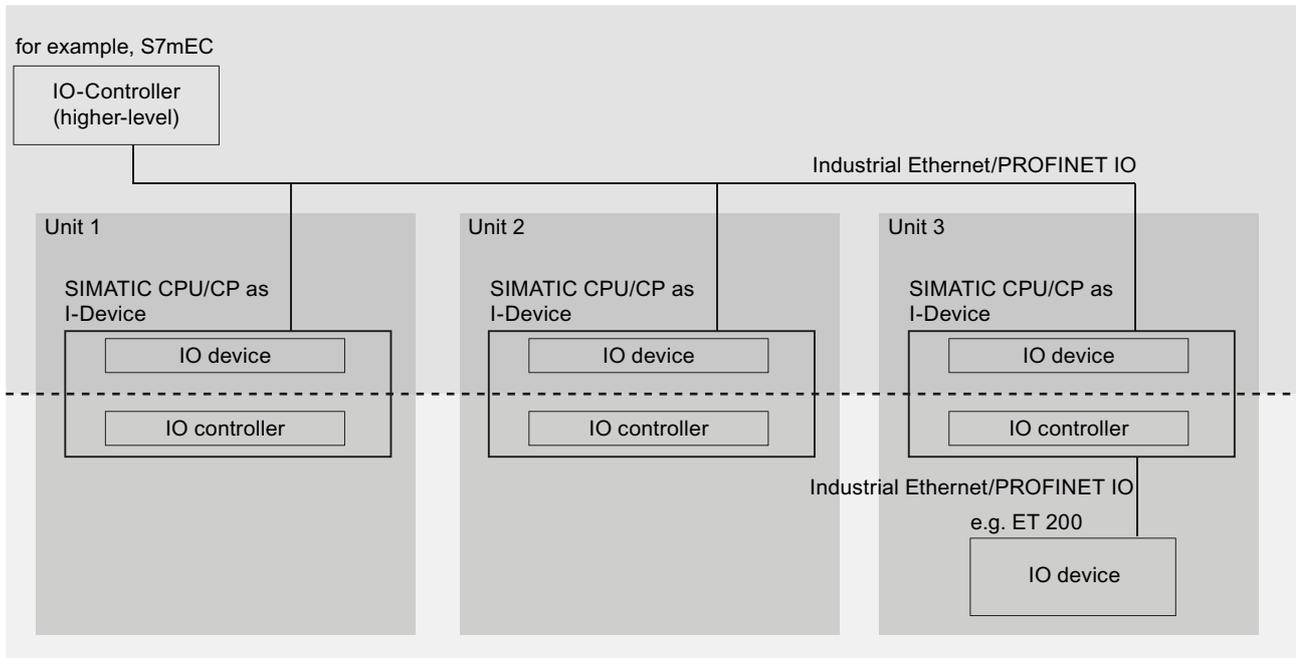
Figure 4-12   Example - the I-device as IO device and IO controller

Unit 1 and unit 2 each consist of an I-device with central I/O. The I-device along with the distributed I/O system (for example ET 200) forms unit 3.

The user program on the I-device is responsible for preprocessing the process data. For this task, the user program of the I-device requires default settings (for example control data) from the higher-level IO controller. The I-device provides the higher-level IO controller with the results (for example status of its subtask).

With suitable configuration, the control data and the results can also be called up directly from the lower-level I/O. This allows the higher-level IO controller direct access to the lower-level I/O.

4.8.1.4 Data Exchange between Higher- and Lower-level IO System

Introduction

The next section shows the data exchange between the higher- and lower-level IO system.

Transfer areas

The data for communication between IO controller and I-device is made available in the transfer areas. A transfer area contains an information unit that is exchanged consistently between IO controller and I-device. You will find more information on configuration and use of transfer areas in the chapter Configuring an I-Device in STEP 7 (Page 103).

There are two types of transfer area:

- Application transfer areas are an interface to the user program of the I-device CPU. Inputs are processed in the user program and outputs are the result of the processing in the user program.

- IO transfer areas forward data from the higher-level IO controller to the I/O or vice versa. There is no processing of the values on the I-device.

The next figure shows the data exchange between the higher- and lower-level IO system. The individual communication relations are explained below based on the numbers.
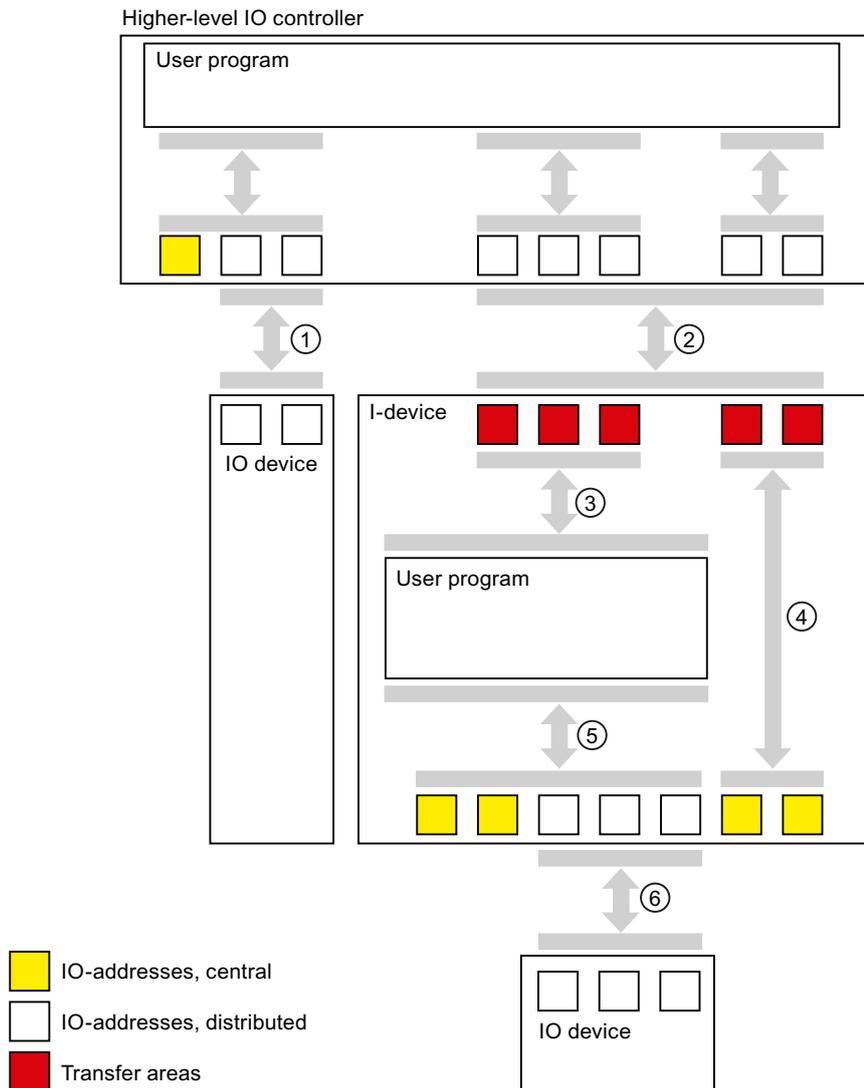
① **Data exchange between higher-level IO-controller and normal IO-device**

In this way, the IO controller and IO device exchange data through PROFINET.

② **Data exchange between the higher-level IO controller and I-device**

In this way, the IO controller and the I-device exchange data through PROFINET.

The data exchange between a higher-level IO controller and an I-device is based on the conventional IO controller / IO device relationship.

For the higher-level IO controller, the transfer areas of the I-devices represent submodules of a preconfigured station.

The output data of the IO controller is the input data of the I-device. Analogously, the input data of the IO controller is the output data of the I-device.

③ **Transfer relationship between the user program and the transfer area**

In this way, the user program and the application transfer area exchange input and output data.

④ **Transfer relationship between the transfer area and the I/O of the I-device**

In this way, the I-device passes on the data of its central I/O to the IO transfer area. The data is not processed by the user program in the I-device.

⑤ **Data exchange between the user program and the I/O of the I-device**

In this way, the user program and the central / distributed I/O exchange input and output data.

⑥ **Data exchange between the I-device and a lower-level IO device**

In this way, the I-device and its IO devices exchange data. The data transfer is via PROFINET.

4.8.2 Configuring an I-Device in STEP 7

Introduction

Two different perspectives must be distinguished during configuration:

- Creating the I-device
- Using the I-device

Chapter Creating an I-device (Page 104) shows how an IO system is configured with an I-device. How to import an existing project and use this for your applications is described in the chapter Using an I-Device (Page 113).

Basic procedure for configuring and programming

Creating the I-device

1. Configuration of the I-device with central and/or distributed I/O modules
2. Assignment of parameters for the PROFINET interface of the I-device
3. Configuration of the transfer areas of the I-device
4. Generation of a GSD file

Using the I-device

1. Installing the GSD file
2. Configuration of the higher-level IO controller
3. Assignment of parameters for the PROFINET interface of the higher-level IO controller with central and distributed I/O modules
4. Configuration of the I-device on the IO system of the higher-level IO controller
5. Programming the user programs

4.8.2.1 Creating an I-device

Configuration example

How you configure a small automation system with an I-device is shown based on an example.

Control tasks and preprocessing are handled by an ET 200S-CPU (IM 151-8 PN/DP CPU) operating as an I-device.

The following graphic shows the configuration of the application. it consists of a higher-level IO system and the I-device. The I-device is first illuminated separately from the higher-level IO system (cone of light from the search light).
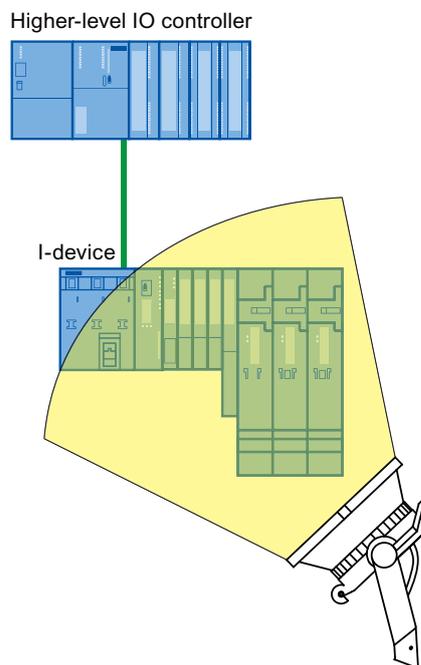
Based on this example, you will see how to do the following:

- configure an I-device
- configure the transfer areas

4.8.2.2   Configure I-device

Preparatory steps

1. Create a project with the name "I-Device Project" in the SIMATIC Manager.

2. Add a new "SIMATIC 300 station" with the name "I-Device".

3. Open the station in HW Config and configure an ET 200S-CPU (IM 151-8 PN/DP CPU).

4. Configure the IP address parameters. Refer to the section IP address parameters in the chapter Constraints on the Use of I-Devices (Page 129).

5. Add the central I/O.

The following figure shows the configuration once you have taken all the steps.
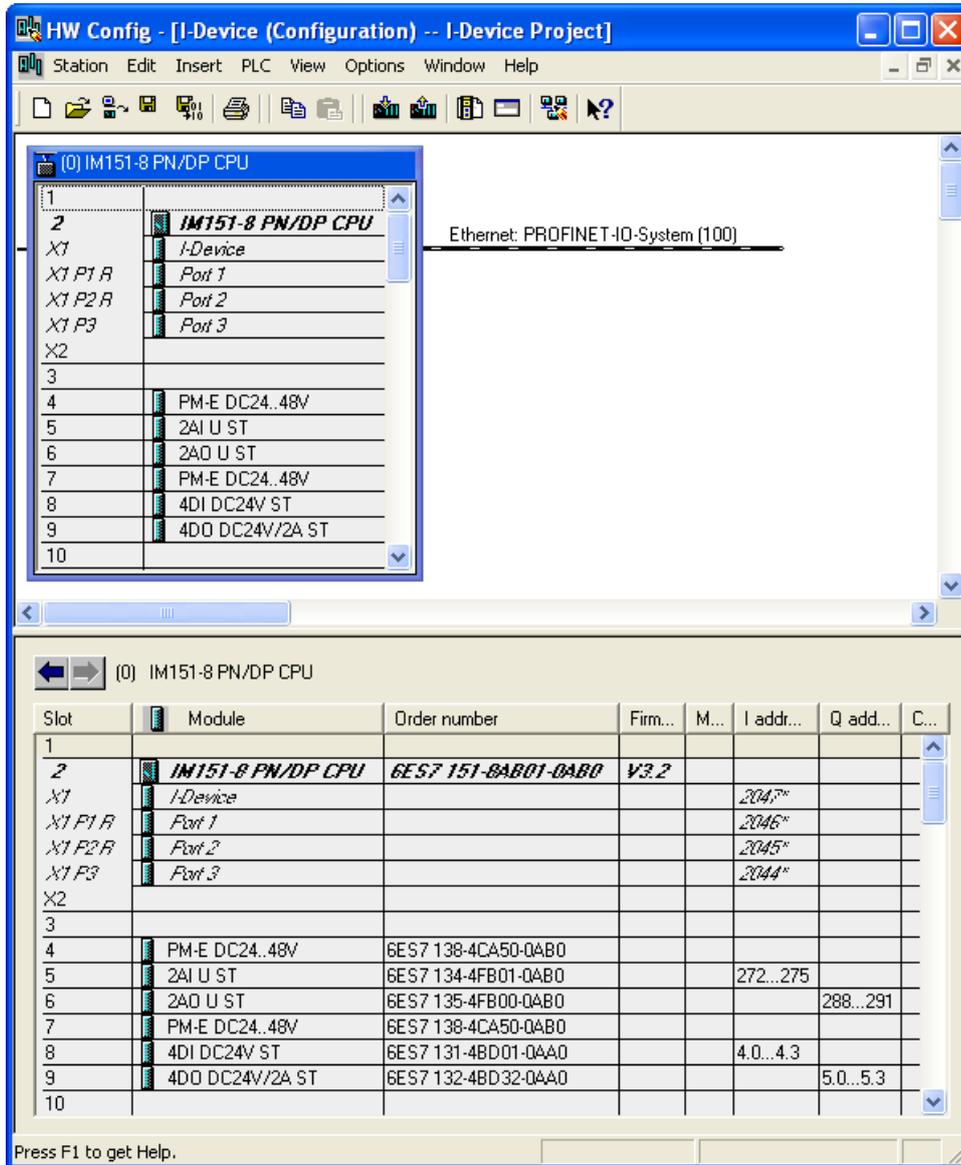
Figure 4-13 $ Configuring the I-Device

Configuring

To be able to use the ET 200S CPU you have just configured as an I-device, you will first need to make several settings in the "I-Device" tab of the interface properties:
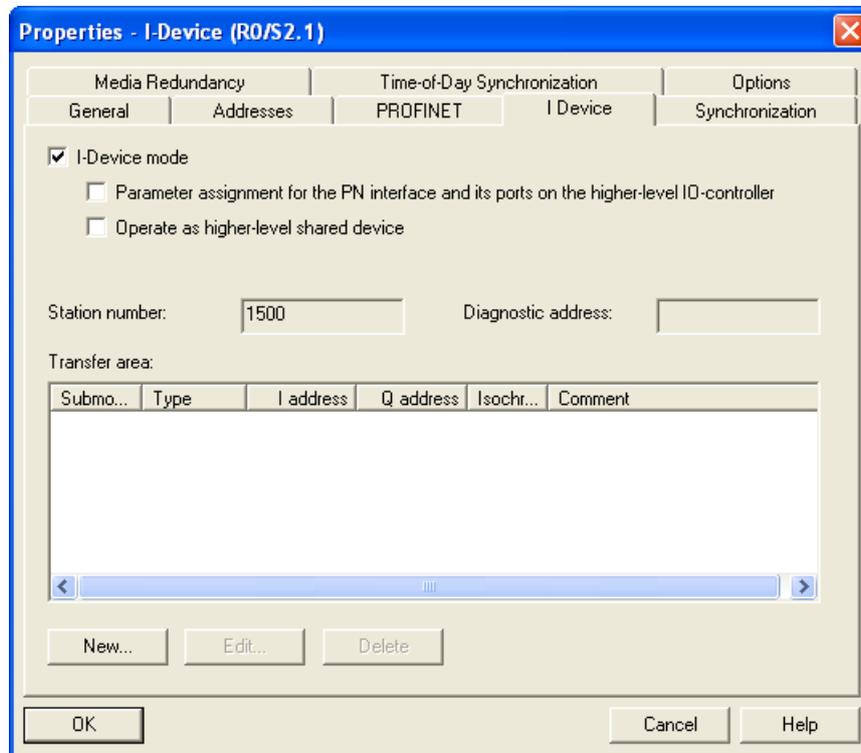
Figure 4-14   "Properties - I-Device" dialog

1. Select the "I-device mode" check box.

2. If the "The "Parameter assignment for the PN interface and its ports on the higher-level IO controller" check box is selected, the interface and port parameters are assigned by the higher-level IO controller. If the check box is not selected, the parameters are assigned in this station.

3. The I-device automatically obtains the specific station number 1500 from STEP 7. This cannot be edited and is therefore unavailable. The station number is part of the geographic address for the transfer areas of the I-device.

4. The settings for the transfer areas are explained in the next section.

4.8.2.3 Configure transfer areas

Configure the transfer areas

In the next step, configure the transfer areas of the I-device. There are two types of transfer areas:

- application transfer areas
- IO transfer areas

Creating an application transfer area

To create an application transfer area, click the "New..." button in the "Transfer area" part of the "I-Device" tab. The "Transfer Area Properties" dialog box opens.
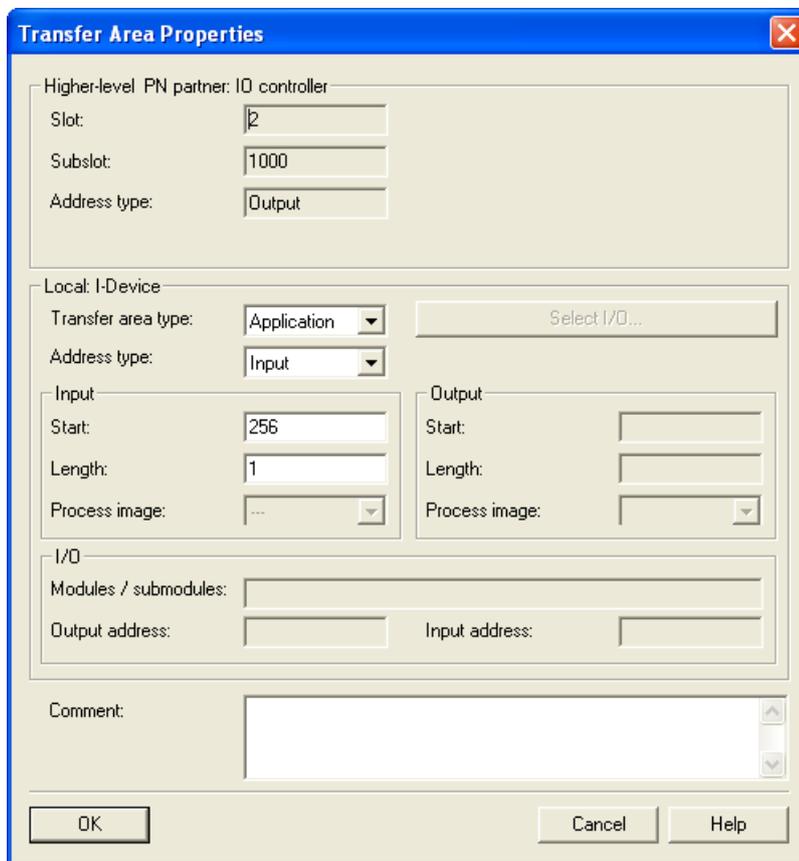
Figure 4-15   "Transfer Area Properties" dialog box

Here, you set the properties of the transfer area; follow the steps below:

1. The "Transfer area type" drop-down list allows you to make the following settings depending on the CPU you are using:

   – "Application"

   – "I/O"

   Select Application for an application transfer area. The values of the transfer area on the higher-level IO controller (slot and subslot) are assigned automatically by STEP 7, the boxes cannot be edited.

2. Specify whether or not the transfer area is to be an input or output transfer area locally. You do this by selecting the relevant address type from the "Address type" drop-down list. STEP 7 assigns the address type of the higher-level IO controller automatically. If the transfer area is to appear on the higher-level IO controller as an output, it must be an input on the I-device and vice versa.

3. Just like every other submodule, a transfer area also requires an address space to be accessed by the user program. You therefore set the start address, length and the process image of the input/output.

4. Enter any additional information as the comment and exit the dialog with "OK".

The transfer area has now been created and is displayed in the "I-Device" tab with its data.

Creating an IO transfer area

To create an IO transfer area, click the "New..." button in the "Transfer area" part of the "I-Device" tab. The "Transfer Area Properties" dialog box opens.

Here, you set the properties of the transfer area; follow the steps below:

1. The "Transfer area type" drop-down list allows you to make the following settings depending on the CPU you are using:

   – "Application"

   – "I/O"

   Select I/O for an I/O transfer area. The values of the transfer area on the higher-level IO controller (slot and subslot) are assigned automatically by STEP 7, the boxes cannot be edited.

   ### Note

   If the "I/O" setting is not available, the CPU you are using does not support I/O transfer areas.

2. Now specify which modules / submodules of the I-device will be available to the higher-level IO controller as IO transfer areas. Click the "Select IO" button. The "IO Transfer Area - Select IO" dialog box will open.

3. Select a module / submodule and exit the dialog with "OK".
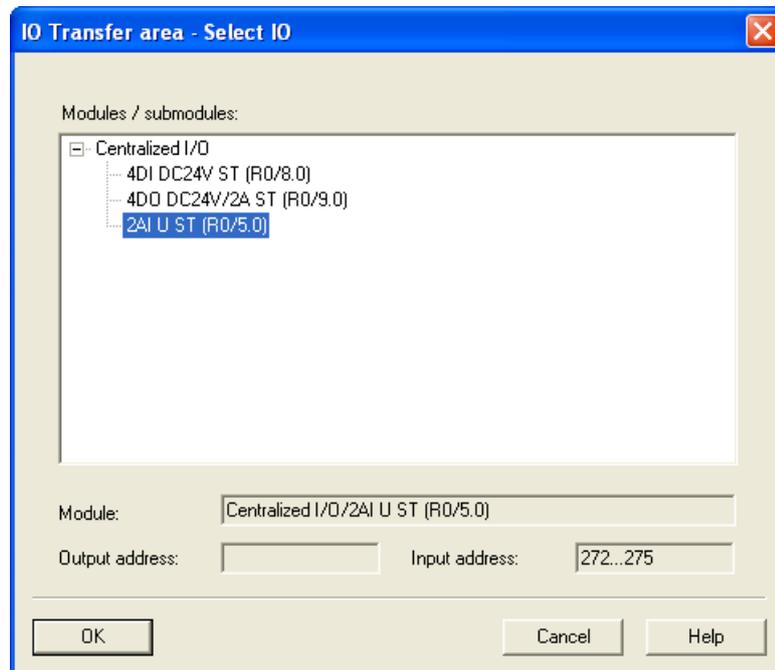
Figure 4-16   "IO Transfer Area - Select IO" dialog box

4. Just like every other submodule, a transfer area also requires an address space to be accessed by the user program. You create this by setting the start address of the input / output. The length is calculated automatically based on the selected module / submodule.

5. Enter any additional information as the comment and exit the dialog with "OK".

The transfer area has now been created and is displayed in the "I-Device" tab with its data.

See also

Diagnostics and interrupt characteristics (Page 120)

4.8.2.4 Generating a GSD File

Generating and importing a GSD file

The next step is to generate a GSD file for the I-device CPU and to store this in the hardware catalog of HW Config or in the file system for other uses.

Procedure

1. Click the menu command **Options > Create GSD File for I-Device** in HW Config.
   The "Create GSD File for I-Device" dialog box opens.

2. The I-device CPU is already set in the "I-device" drop-down list.
   The identifier assigned in the "Identifier for generic I-device" box is the later name of the generic I-device that will be shown on the higher-level IO controller. The box has the device name as default. You can assign the name yourself according to the rules of the DNS conventions.

   Note

   - If more than one I-device CPU is configured in a rack, you will need to select the I-device CPU from the "I-device" drop-down list.

   - If the device name is obtained by a "different method" the physical address of the I-device CPU will be assigned as the identifier for the generic I-device,
     for example "R0S2.5" (corresponds to rack 0 slot 2.5).
   ---

3. Now create the GSD file by clicking the "Create" button. If the file was created successfully, the "Install" and "Export" buttons will be visible and the name of the GSD file is displayed.

4. The GSD file you have just created can now be installed and/or exported using the relevant buttons:

   – "Install" button: The GSD file is installed on your computer and included in the hardware catalog in "PROFINET IO -> Preconfigured Stations -> CPU Name" under the assigned identifier.

   – "Export" button: The GSD file can be exported to another computer for later use or for archiving purposes in the file system.

   Note

   The GSD file can be installed in HW Config using the menu command
   Options > Install GSD Files....
   ---

5. Close the "Create GSD File for I-Device" dialog box and save and compile the hardware configuration and then close HW Config and the project.

4.8.2.5 Using an I-Device

Introduction

The created I-device will now be used in a higher-level IO system.

Configuration example

Once the I-device has been configured and its parameters set, we move on to the higher-level IO system.

Note

The higher-level IO system does not necessarily need to be in the same STEP 7 project as the I-device. If the higher-level IO system is configured on another computer, you will need to make sure that the GSD file of the I-device was installed.
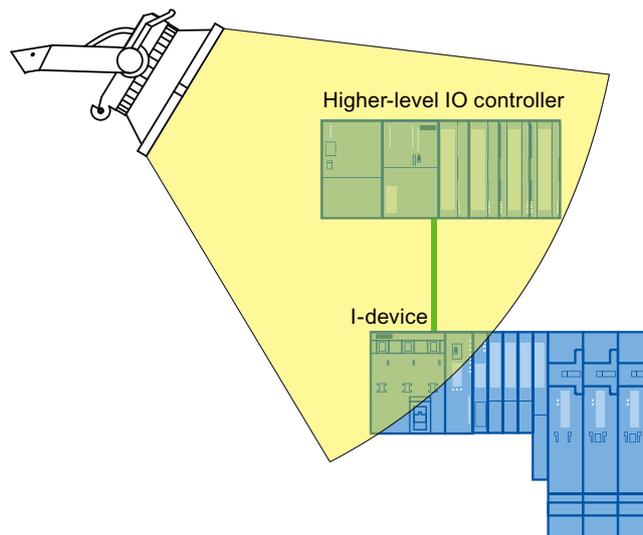
The following steps are explained based on this example:

- Configuring the I-device in the higher-level IO system
- Access to the transfer areas

See also

Creating an I-device (Page 104)

4.8.2.6 Configuring the high-level IO system

Requirements

As described in the earlier sections, you have configured an I-device and generated and installed the GSD file.

Fundamental steps

1. Create a 300 station as a higher-level IO controller with the name "IO controller".

2. Open the station in HW Config and configure a CPU 319-3 PN/DP with a PROFINET IO system.

3. Configure the central and distributed I/O.

4. The following figure shows the configuration once you have taken all the steps.
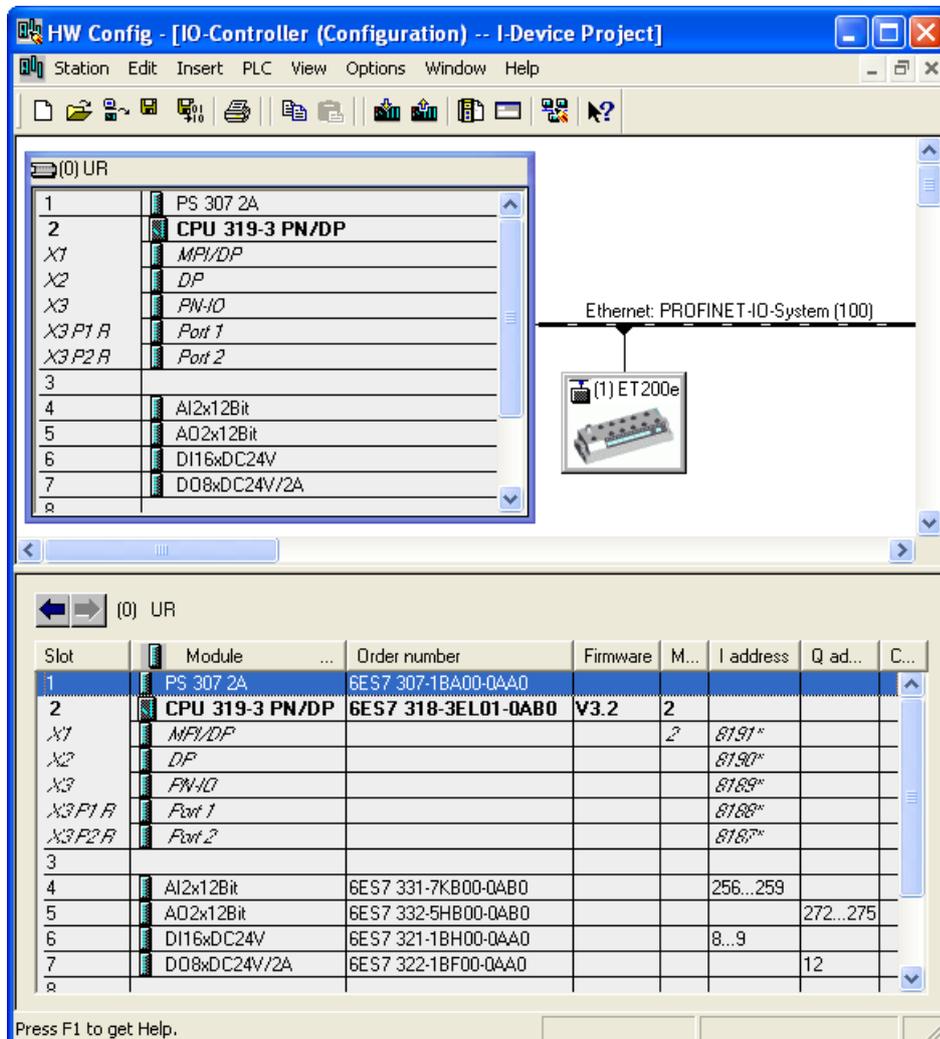
Figure 4-17   Higher-level IO system

Configuring

To be able to use the I-device on the higher-level IO system, the I-device GSD file must have been installed earlier (see chapter Generating a GSD File (Page 112)).

Follow the steps below to be able to operate the I-device with the higher-level controller:

1. Go to the hardware catalog of HW Config to the "PROFINET IO -> Preconfigured Stations" folder and select the I-device you configured there

2. Drag your I-device to the previously created PROFINET IO system.

Result: The I-device in included in the higher-level IO system. The transfer areas created on the I-device can now be addressed by the user program of the higher-level IO controller.

See also

Configure I-device (Page 105)

4.8.2.7 Example of a User Program

Introduction

This simple program example explains how the preprocessing can be implemented with an I-device. The second part of the example explains access to an IO transfer area of the I-device from the user program of the higher-level controller.

Preprocessing on the I-device

Task

The result of a simple "AND" operation on the I-device will be made available on the higher-level IO controller for further processing.

Requirement

You have configured an application transfer area on the I-device with the following properties:

- Local I-device address type: Output
- Start address 568, length 1

Solution

Table 4- 6   AWL-Code: I-device

STL
U   I 1.0
U   I 1.1   // AND-link from E1.0 (Sensor 1) and E1.1 (Sensor 2)
=   A 568.0   // Write result of operation to A568.0 (application transfer area of the I-device)

Table 4- 7   AWL-Code: Higher-level IO controller

STL
U   I 68.0   // corresponds with the A568.0 of the I-device
=   A 0.0   // sets the initial state of A0.0

Note

The addresses of the transfer areas are preset by HW Config. The addresses can, as usual, be changed by the user. In this case, the byte address E 68 was specified for the transfer area.

Access to IO transfer areas

Task

The input word of an IO component placed in the I-device CPU (analog value of channel 0 from an analog entry component) should be made available to the higher level IO controller.

Requirement

You have configured an IO transfer area on the I-device with the following properties:

- There is a basis of an input module configured as central I/O on the I-device CPU.
  In this case, the module "2AI U ST" in slot 5 with logical address 272..275

- Output address in the IO transfer area of the I-device: 223..226

Solution

Table 4- 8   AWL-Code: I-device

STL
`// No change necessary in user program`

No programming is necessary in the user program of the I-device to make the IO transfer areas available. The IO transfer areas are provided by the operating system of the I-device CPU.

Table 4- 9   AWL-Code: Higher-level IO controller

STL

L   PEW 26   `// Load IO input word 26 (content of the process data transferred through the`
`IO transfer area to the higher-level IO controller (analog value of channel 0)`
`of the analog component inserted centrally in the I-device)`

Note

Addresses

The addresses of the transfer areas are preset by HW Config. The addresses can, as usual, be changed by the user. In this case, the address range 26..27 was fixed for the transfer area (the transferred process values of the analog components inserted centrally in the I-device).

NOTICE
Access to output IO
In the user program from the I-device, outputs that belong to an IO transfer area may not be directly accessed.

4.8.2.8 I-device with subordinate IO system

Distributed I/O on the I-device

The I-device mode also supports operation of distributed PROFIBUS DP or PROFINET IO.

Higher-level IO controller

I-device

lower-level
IO-system
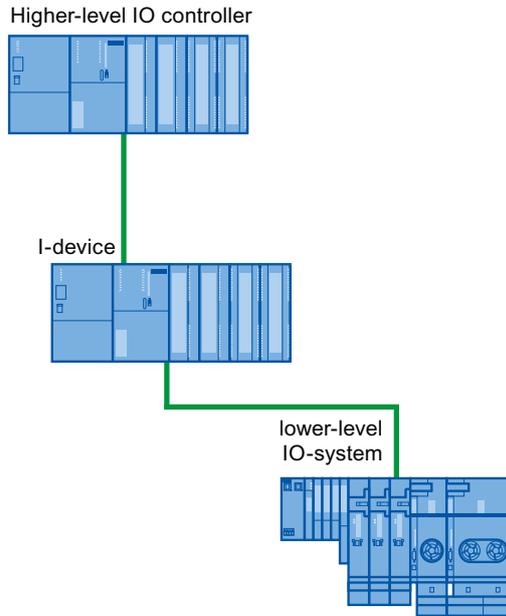
How to configure distributed I/O

The procedure for configuring distributed I/O below an I-devices is exactly the same as the familiar procedure when configuring distributed I/O.

Note

Setting the PROFINET interface of S7-CPUs as I-devices

If you operate an I-device with a lower-level IO system, the PROFINET interface (for example, port parameter) of this I-device cannot be set through the higher level IO controller. This results in it being impossible to have an IRT operation for this I-device on higher-level IO controllers.

Preparatory steps

1. Create a project with the name "I-Device Project" in the SIMATIC Manager.

2. Add a new "SIMATIC 300 station" with the name "I-Device".

3. Open the station in HW Config and configure an ET 200S CPU with a PROFINET IO system.

4. Add a PROFINET IO-device ET 200S (for example IM151-3 PN ST) with inputs and outputs.

The following figure shows the configuration once you have taken all the steps.
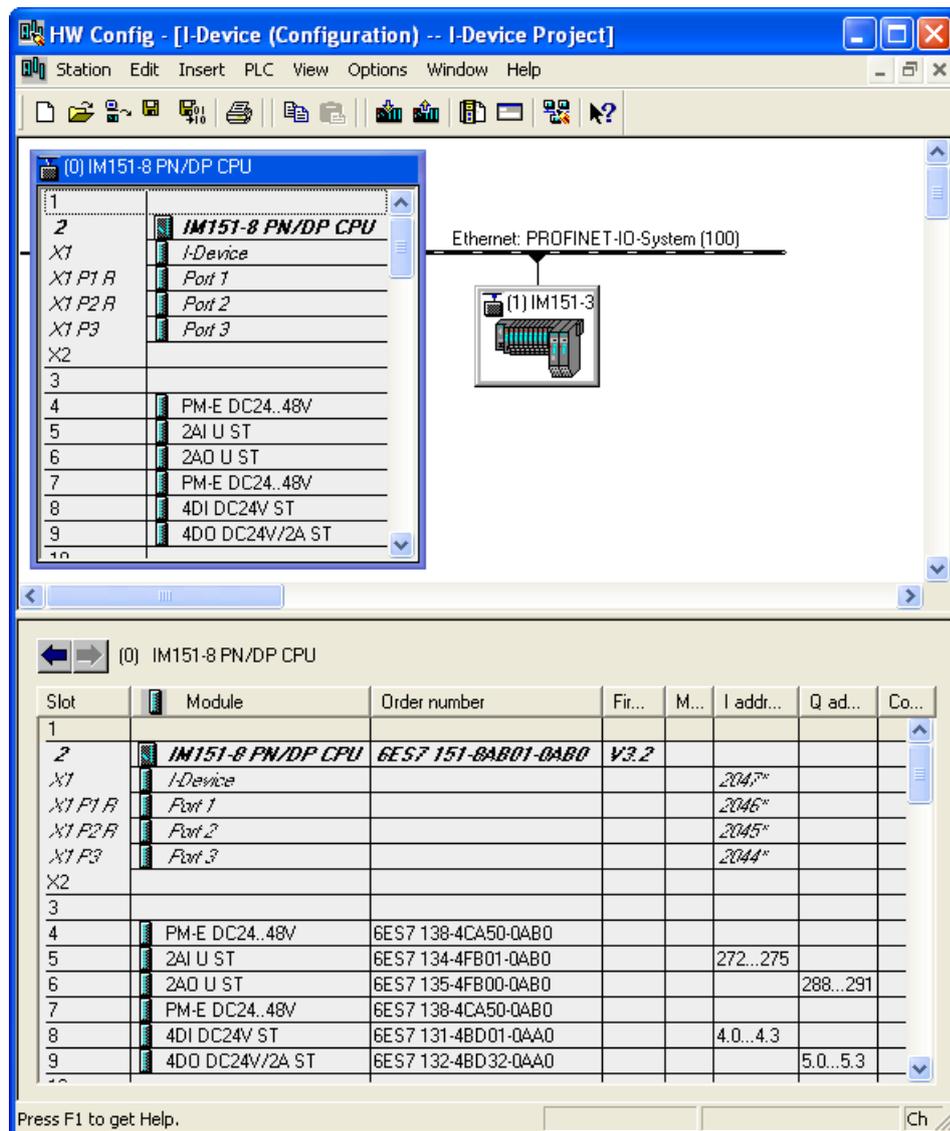
Figure 4-18   Configure an I-device with a lower-level IO system

Creating an I-device

In order to create the I-device, follow the descriptions in chapter Configure I-device (Page 105). The rest of the steps are the same as described there.

4.8.2.9   Configure I-device as shared device

Introduction

With only a few configuration steps, an I-device can also be used as a shared device.

Configuring

To configure an I-device as a shared device, follow the steps below:

1. Configure an I-device as described in chapter Configure I-device (Page 105).
2. Configure the transfer areas as described in the chapter Configure transfer areas (Page 108).
3. Reopen the "I-Device" tab of the interface properties of the CPU.
4. Select the "Operate as higher-level shared device" check box and exit the dialog with "OK".
5. Create the GSD file as described in chapter Generating a GSD File (Page 112).
6. The created GSD file can be configured as a shared device as described in the chapters under Engineering (Page 88).

4.8.3   Diagnostics and interrupt characteristics

Diagnostics and interrupt characteristics

S7 CPUs have numerous diagnostics and interrupt functions that can, for example, report errors/faults or failures of underlying IO systems. These diagnostic messages reduce down times and simplify localization and elimination of problems.

General distinction

The diagnostics and interrupt functions known from "normal" S7 CPUs are also available when using I-devices. There are, however, several special features of diagnostics of I-devices. The explanations are organized as follows:

- Diagnostics of the I-device on the higher-level IO controller
- Diagnostics on the I-device CPU

Diagnostics of the I-device on the higher-level IO controller

The higher-level IO controller has the following mechanisms available for diagnosing the condition of the I-device:

- OB 83 (Return-of-Submodule-Alarm)
- OB 85 (process image transfer error)
- OB 86 (component / CPU stop)
- OB 122 (I/O Access Error)

Special features of IO transfer areas:

When using IO transfer areas, only the transfer area itself can be diagnosed (exists, available) but not the underlying I/O module of the centrally inserted I-device CPU.

Note

- Failures of the centrally inserted IO of the I-device are reported in the higher-level IO controller only with direct access from the user program (for example, L PEB, T PAB) to the corresponding transfer area (call of OB 122) and during the recognition of process image transfer errors (call of OB 85 if configured in HW-Config).

- The IO components are assigned to IO transfer areas, they can only be set in the I-device CPU.

- Process and diagnosis alarms from IO components assigned to IO transfer areas are not directly reported to the higher level IO controller. The evaluation of alarms and the forwarding of the corresponding alarm information to the higher-level controller must occur in the I-device user program (for example, forwarding alarm information through an application transfer area).

- Load voltage diagnostics for the IO module that are in the group of a power module (for example, with IM151-8 PN/DP CPU) can only be solved by application (as described in the previous point), the same applies for plugging in / pulling a power module.

- The higher-level IO controller cannot read/write any datasets from/to IO components (that are assigned to IO transfer areas).

Diagnostics options of the I-device CPU

Diagnostics within the I-device differs from the diagnostics options in "normal" IO systems:

For the I-Device CPU, it is important to know whether the higher-level controller is in STOP or RUN and whether the higher-level IO-controller accesses the transfer areas of the I-device CPU in a cyclical manner. The following methods can be used:

- OB 83 (Insert/remove and return of submodule alarm)
- OB 85 (process image transfer error)
- OB 86 (component / CPU stop)
- OB122 (IO access error)

Note

The diagnostic messages of the I/O can be processed in the user program of the I-device CPU and passed on from there to the higher-level IO controller via transfer areas.

Operating state changes and station failures / station returns

With a system configuration with I-Device, multiple CPUs are normally used. In the following tables, you can see which consequences the operating state change or the failure of individual CPUs (I-device, IO-controller) have on the respective other(s):

Events

Initial status	Event	I-device response	Response of higher-level controller
Both CPUs are in RUN.	The I-device CPU changes to STOP.	/	Call of OB 85 (process image transfer error for all input and output submodules of the transfer areas to the I-device which are located in the process image, provided a message for process image transfer errors has been configured.) With direct IO access to input or output submodules of the transfer areas to the I-device: Call of OB 122 (access error).
I-device CPU is in STOP, higher-level controller is in RUN.	The I-device CPU is starting up.	Call of OB 100 (startup). Call of OB 83: Return of submodule alarms (sub module return) for input submodules from the transfer areas to the higher-level controller. Up until opening the return of submodule alarm, there may be access errors when accessing input submodules of the transfer areas to the higher level controller: Call of OB 122 (direct access) and OB 85 (if access error message through process image transfer has been configured).	Call of OB 83: Return of submodule alarms (sub module return) for input and output submodules from the transfer areas to the I-device. Until the return of submodule interrupts is called, accessing the input and output submodules of the transfer areas to the I-device continues to result in OB 122 (direct access) or OB 85 (with configured access error message via process image transfer) being called.
Both CPUs are in RUN.	The higher-level IO controller changes to STOP	Call of OB 85 (process image transfer error for all input submodules of the transfer areas to the higher-level controller that are located in the process image, provided a process image transfer error message has been configured). Opening OB 122 (with direct access to input transfer areas). Note: Output transfer areas can still be accessed.	/

Initial status	Event	I-device response	Response of higher-level controller
Higher-level IO controller is in STOP, I-device CPU in RUN.	The higher-level IO controller starts up.	Call of OB 83: Return of submodule alarms (sub module return) for input submodules from the transfer areas to the higher-level controller. Until the return of submodule interrupts is called, accessing the input and output submodules of the transfer areas to the higher-level controller continues to result in OB 122 (direct access) or OB 85 (with configured access error message through process image transfer) being called.	Call of OB 100 (startup).
Both CPUs are in RUN.	Station failure I-device, for example, through bus disruption	If the I-device continues to run without a bus connection: Opening OB 86 (station failure and partial station failure when operating as shared device). Call of OB 85 (process image transfer error) for all input and output submodules of the transfer areas to the higher-level controller that are located in the process image, provided process image transfer error messages have been configured. Call of OB 122 (in the case of direct access to the input and output submodules of the transfer areas to the higher-level controller).	Opening OB 86 (station failure). Call of OB 85 (process image transfer error) for all input and output submodules of the transfer areas to the I-device which are located in the process image if a process image transfer error message is configured. Call of OB 122 (in the case of direct access to the input and output submodules of the transfer areas to the I-device).

Initial status	Event	I-device response	Response of higher-level controller
Both CPUs in RUN, the communication connection between the IO-controller and I-device is disrupted (bus disruption).	The bus connection between the IO-controller and I-device is reestablished and the I-device is recorded in the usage data traffic again.	Opening OB 86 (station return and partial station return when operating as shared device). Call of OB 83: Return of submodule alarms (submodule return) for input submodules from the transfer areas to the higher-level IO-controller. Until the return-of-submodule interrupts is called, accessing the input and output submodules of the transfer areas to the higher-level controller continues to result in OB 122 (direct access) or OB 85 (with configured access error message through process image transfer) being called.	Opening OB 86 (station return) Until the station return message via OB 86: Call of OB 85 (process image transfer error) for all input and output submodules of the transfer areas to the I-device which are located in the process image, provided a process image transfer error message has been configured. Also, call of OB 122 (in the case of direct access to the input and output submodules of the transfer areas to the I-device).

Particularity when starting up the I-device

In contrast to the station return message from IO-devices in the IO-controller, which are covered by completely opening the OB 86, the station return message of a higher-level IO -controller is separated into 2 parts:

1. Call of OB 86: The initial values for the outputs of the I-device are set. The input values, however, are not yet valid; they first become valid when the OB86 is called in the higher-level IO controller.

2. Call of OB 83 for each input transfer area; this call displays the validity of an input transfer area. I-device startup is not complete until OB 83 is called for the input transfer areas. This step can be delayed or not occur at all in the following situations:

   – Higher level IO controller is in STOP: OB 83 is opened first with the STOP-RUN transfer of the higher-level IO controller.

   – The IRT communication with the "high performance" option is disrupted (sync master failure, topology error, ...). Call of the OB 83 occurs only when the IRT communication with the "high performance" option has occurred.

4.8.4 Rules for the Topology of a PROFINET IO System with I-Device

Introduction

The following recommendations for the structure and configuration of an IO system when using I-devices will help you to keep the bandwidths required for keeping communication small.

Basically, the main concern is that the following communications paths do not cross:

● Communication paths between the IO-controller and the IO-device of its IO-system.

● Communications paths of the I-device controller and the IO-devices of its IO-system.

I-device with one port

Connect an I-device with only one port to a switch that is uncoupled from the higher-level IO system. Connect the lower-level IO system to another port of the switch as shown in the following figure.
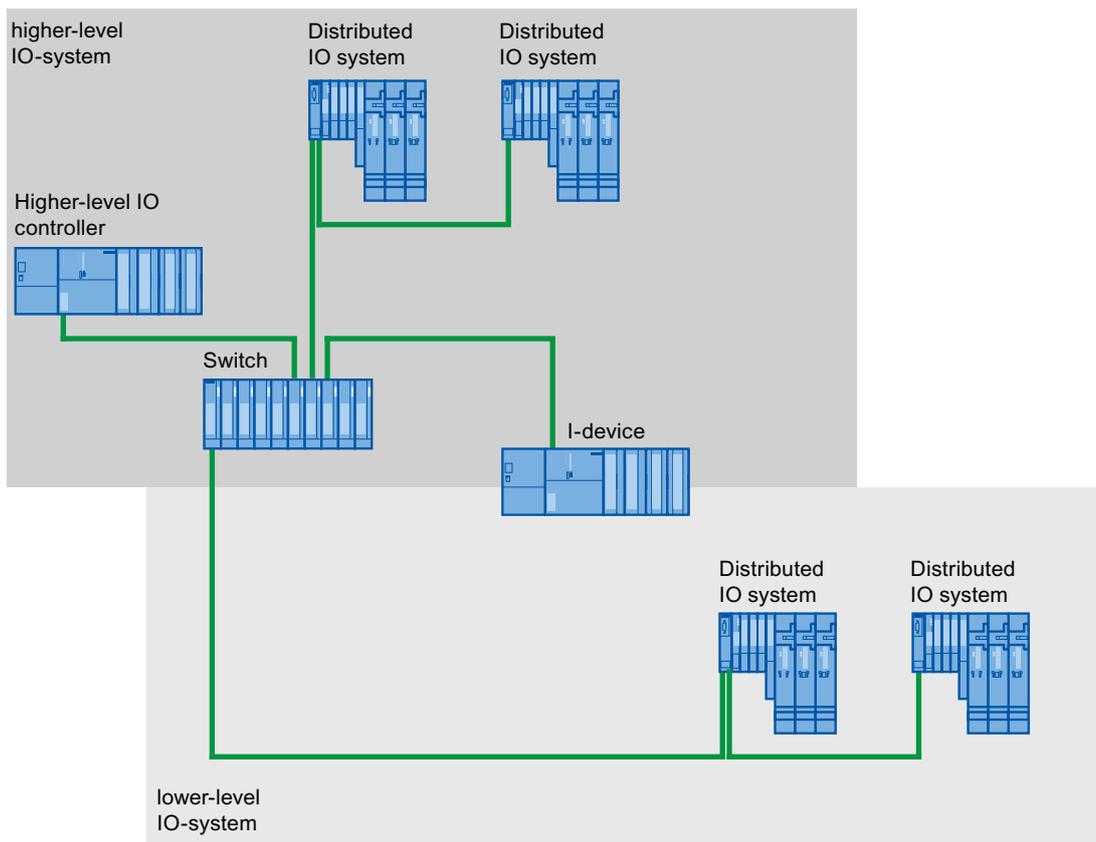
I-device with two ports

With an I-device with two ports, connect one port uncoupled from the higher-level IO system to the port of the switch. Use the second port for the lower-level IO system as shown in the following figure.
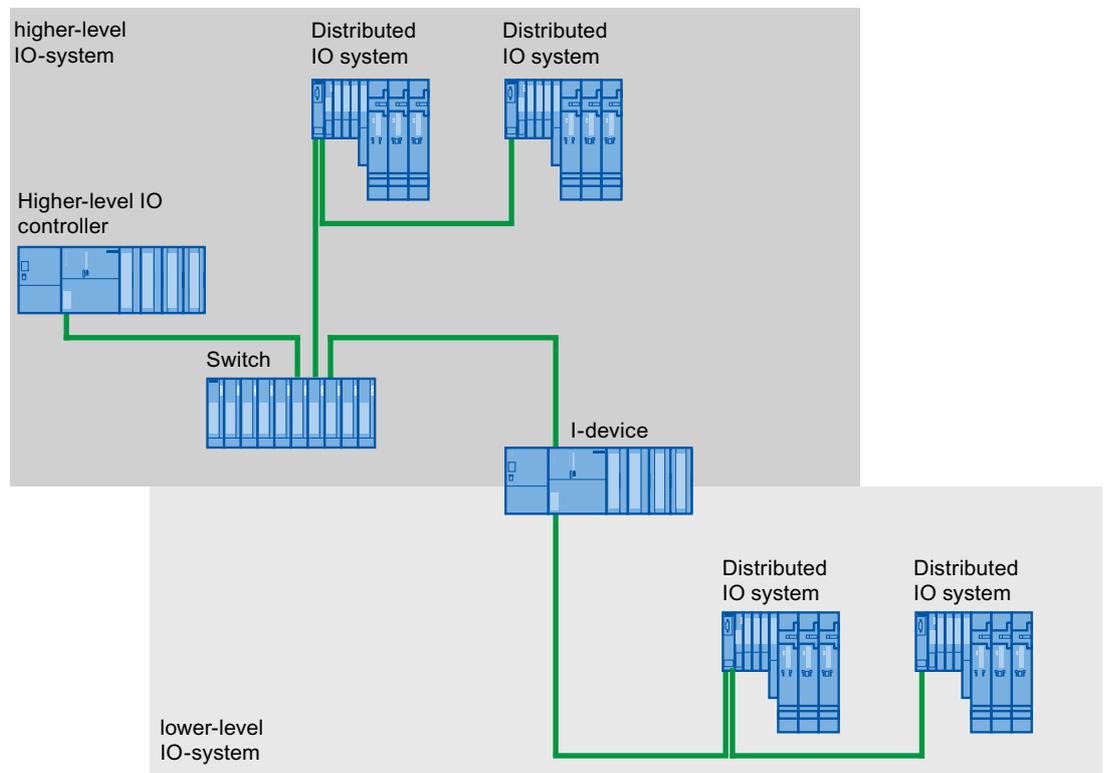
I-device with three or more ports

If you have an I-device with three or more ports, connect the I-device to one or both ports to the higher-level IO system in a linear bus topology. Connect the third port to the lower-level IO system uncoupled from the bus topology as shown in the following figure.
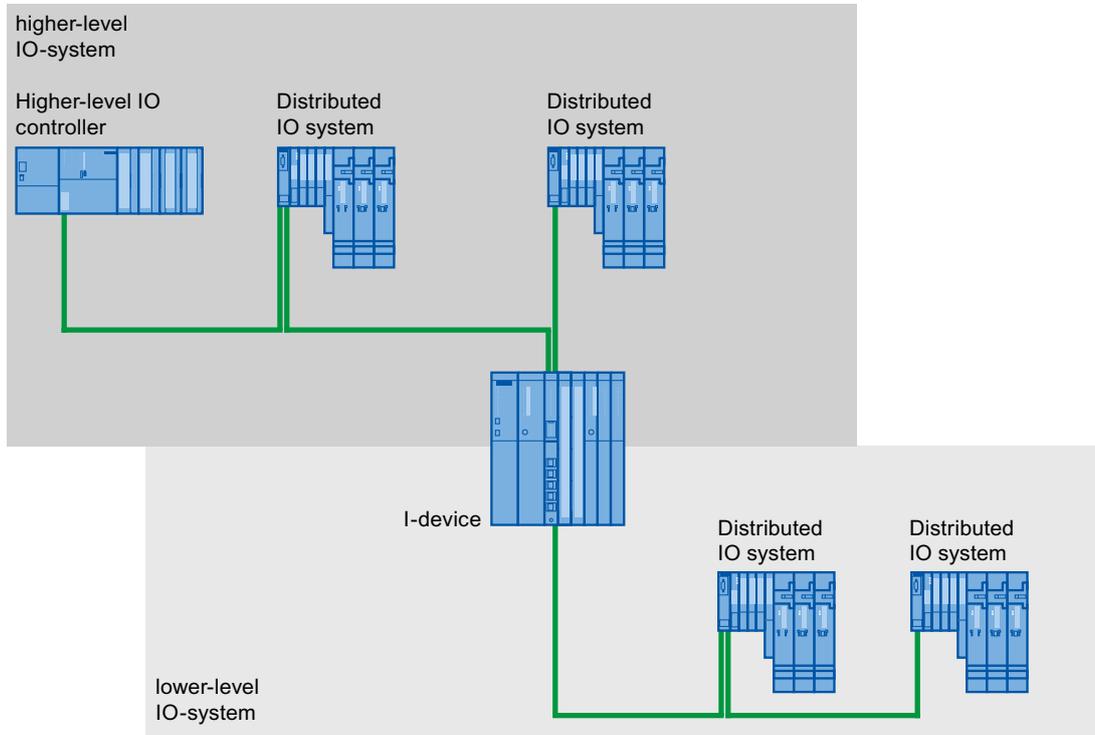
4.8.5 Constraints on the Use of I-Devices

Boundary conditions

When using I-devices, certain constraints must be taken into account in certain situations.

Bandwidth

The number of addresses of the configured transfer areas is reflected in the usable bandwidth of the I-device:

Bandwidth of the transfer areas + bandwidth of the lower-level IO system = total bandwidth used on the I-device

If the address space of the transfer areas is too large, there is not enough bandwidth for the lower-level IO system to achieve fast update times.

Tip: Keep the address space of the transfer area as small as possible.

Rules for RT and IRT communication

IO systems with an I-device are suitable for setting up real-time applications with RT and IRT communication (with the IRT-option "high performance"). Here, the following rules must be kept to:

- Both the higher-level and the lower-level IO system support RT communication.
  You can use RT communication for both IO systems at the same time.

- IRT communication can be combined with RT communication. IRT communication can, however, not take place in both IO systems at the same time.

PROFINET CBA

You cannot operate the I-devices with PROFINET CBA.

Isochronous mode

You cannot operate I-devices in isochronous mode on the higher-level IO controller.

Rules for data access

The higher-level IO controller can access transfer areas:

- If the I-device is in RUN.

Only the application transfer areas may be accessed in the I-device CPU:

- Access to input-application transfer areas possible if the higher-level IO-controller is in RUN.

- Access to output application transfer areas possible independent of the operating state of the higher-level IO controller.

Characteristics of the I/O of IO transfer areas

The I/O of the I-device available to the higher-level IO controller as an IO transfer area behaves as follows:

- Output: If the I-Device CPU and the higher-level controller are in RUN and the IO exists and is available, the value written by the higher-level IO-controller to the IO transfer area is output. If the I-Device CPU and/or the higher-level IO controller are in STOP, replacement values (0, last value or replacement value, depending on the functions and setting of the IO components) are emitted.

Note

Replacement values for the IO of IO transfer areas must be configured in the I-Device CPU.

Note

If the IO does not exist or is not available, then an IO access error will be reported in the higher-level IO controller. This is also the case if the I-device CPU is in STOP.

- Input: If the IO is available and the I-device CPU is in RUN, then the higher-level controller takes over the value of the IO from the IO transfer area. If the IO is not available and the I-device CPU is in STOP, then there will be an IO access error in the higher level IO controller when accessing the corresponding input sub module of the transfer area.

IP address parameters and device name

Just like every other IO device, an I-device also requires IP address parameters / device name to be able to communicate via PROFINET. IP address parameters consist of three parts, the IP address itself, the subnet mask and the address of the router (gateway).

The IP address parameters / device name for an I-device can be assigned in two ways:

IP address parameter / device name via project:

The IP address parameters / device name are permanently assigned during configuration (in the I-device project) in STEP 7. This is the standard method.

Use different method to obtain IP address parameters / device name:

- IP address parameter / device name via DCP: The IP-address parameter / device name are assigned per DCP (Discovery and Configuration Protocol). This can happen in two ways:

  - Using a setup tool such as PST or STEP 7 (via accessible nodes).

  - Through the higher-level I/O controller

- IP address parameter / device name via user program: The assignment of the IP address parameters occurs in the user program of the I-device CPU (through the SFB104).

Note

Topology illustration

If the device name and the IP address parameters are obtained for an I-Device "in a different way", the I-Device can be displayed multiple times in the topology editor.

4.9 Isochronous mode

4.9.1 What is isochronous mode?

Objectives of isochronous operation

Assuming public transport were to operate at maximum speed while reducing stop times at the passenger terminals to absolute minimum, the last thing many potential passengers would notice of the departing contraption are its red tail lights. The overall travel time is, however, decided by the train, bus or underground clock, because well adjusted timing is essential to a good service. This also applies to distributed automation engineering. Not only fast cycles but also the adaptation and synchronization of the individual cycles result in optimum throughput.

Just-In-Time
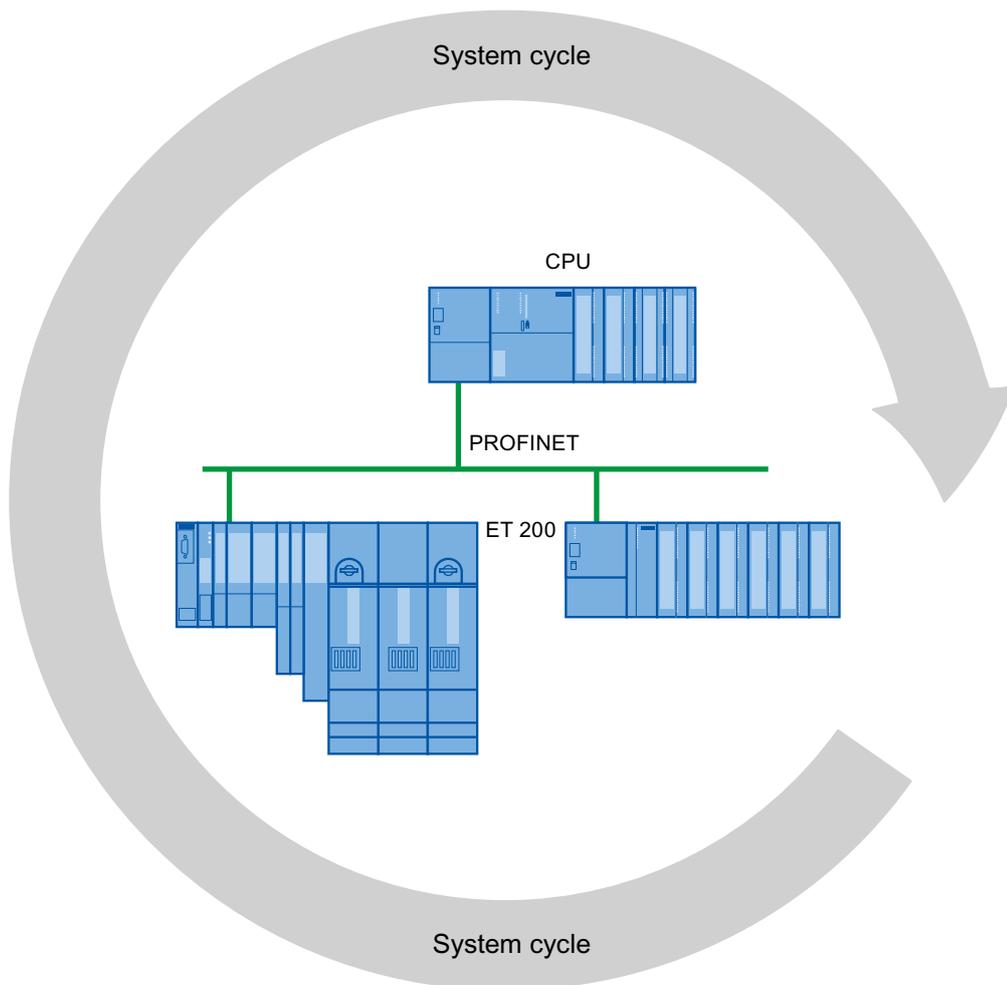
The high speed and reliable reaction time of a system operating in isochrone mode is based on the fact that all data are provided just-in-time. The constant PROFINET IO cycle beats the time here.
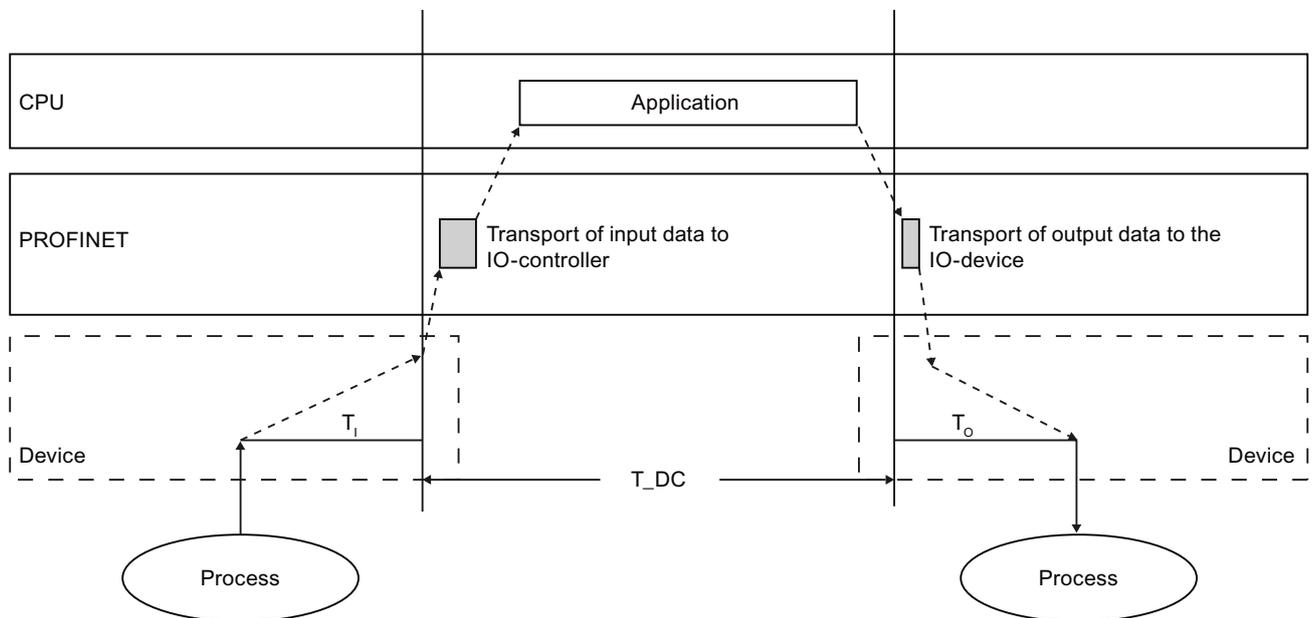
T_DC   Date cycle

T_I Time for reading

T_O Time for outputting the output data

To ensure that all input data is ready for transportation via the PROFINET IO line when the next PROFINET IO cycle begins, the IO read cycle has a lead time T_I so that it starts earlier. T_I is the "flash gun" for all inputs. This T_I is necessary to compensate for analog to digital conversion, backplane bus times etc. The bias time T_I can be configured by STEP 7 or by the user. We recommend automatically assigning the bias time T_I of STEP 7.

The PROFINET IO line transports the input data to the IO controller. The synchronous cycle interrupt OB (OB 61, OB 62, OB 63 or OB 64) is called. The user program in the synchronous cycle interrupt OB decides the process reaction and provides the output data in time for the start of the next data cycle. The length of the data cycle is always configured by the user.

T_O is the compensation from the backplane bus and the digital to analog conversion within the device. T_O is the "flash gun" for all inputs. The time T_{IO} can be configured by STEP 7 or by the user. We recommend automatically assigning the bias time T_O of STEP 7.

Advantages of isochronous mode

T_I and T_O set equal by the system, allows to simultaneously capture values with the flash gun and thus, make a consistent snapshot of the values.

Advantages of using isochronous mode:

- When acquisition of measured values needs to be synchronized, movements need to be coordinated and process reactions need to be defined and take place simultaneously

- Simultaneous acquisition of signals for control processes, measurement and motion control tasks regardless of location

Isochronous mode and non isochronous mode distributed I/O

It is possible to combine isochronous mode distributed I/O with non isochronous mode distributed I/O on one IO controller.

4.9.2 Isochronous applications

Example: Isochronous measurement at several measuring points

QC requires precise measurement of dimensions within a camshaft production process.
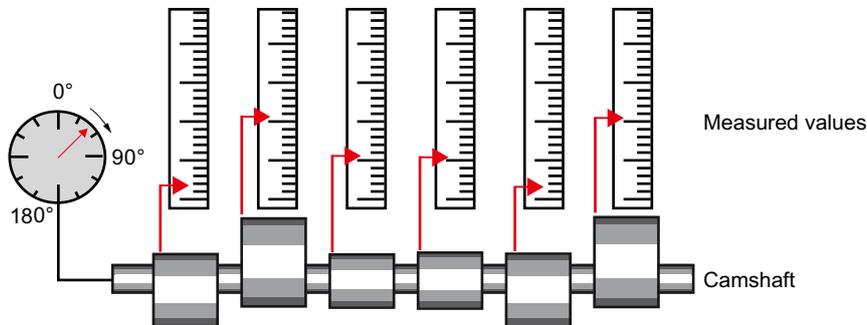
Isochronous workflow

By using the system property "isochronous mode" and the associated simultaneous measured value acquisition, measurement can be performed continuously and the time required for measurement is reduced. Resultant workflow:

- Continuous machining of the camshaft

- During the continuous turning, measure the positions and cam excursion synchronously

- Process the next cam shaft

All camshaft positions and the corresponding measured values (red) are measured synchronously within a single rotation of the camshaft. This increases machine output and maintains or enhances precision of the measurement.

4.9.3 How Does Isochronous Mode Work?

PROFINET IO allows for isochronous operation

The essential basis for synchronized processing cycles is the constant PROFINET IO bus cycle time. The system property "isochronous mode" links the SIMATIC automation solution to the constant PROFINET IO bus cycle time.

That is:

- The importing of input data T_I is normal for the data cycle. The time T_I moves the reading in of the values back by a fixed time.

- The user program for processing the IO data is synchronized with the data cycle by the synchronous cycle interrupt OBs OB 61 to OB 64.

- The output of the initial data T_O is standard for the data cycle. The time T_O moves the output forward by a fixed time.

- All input and output data are transferred consistently. That is, all data of the process image are associated logically and based on the same timing.

T_DC   Date cycle

T_I Time of import for data input

T_O Time of data output
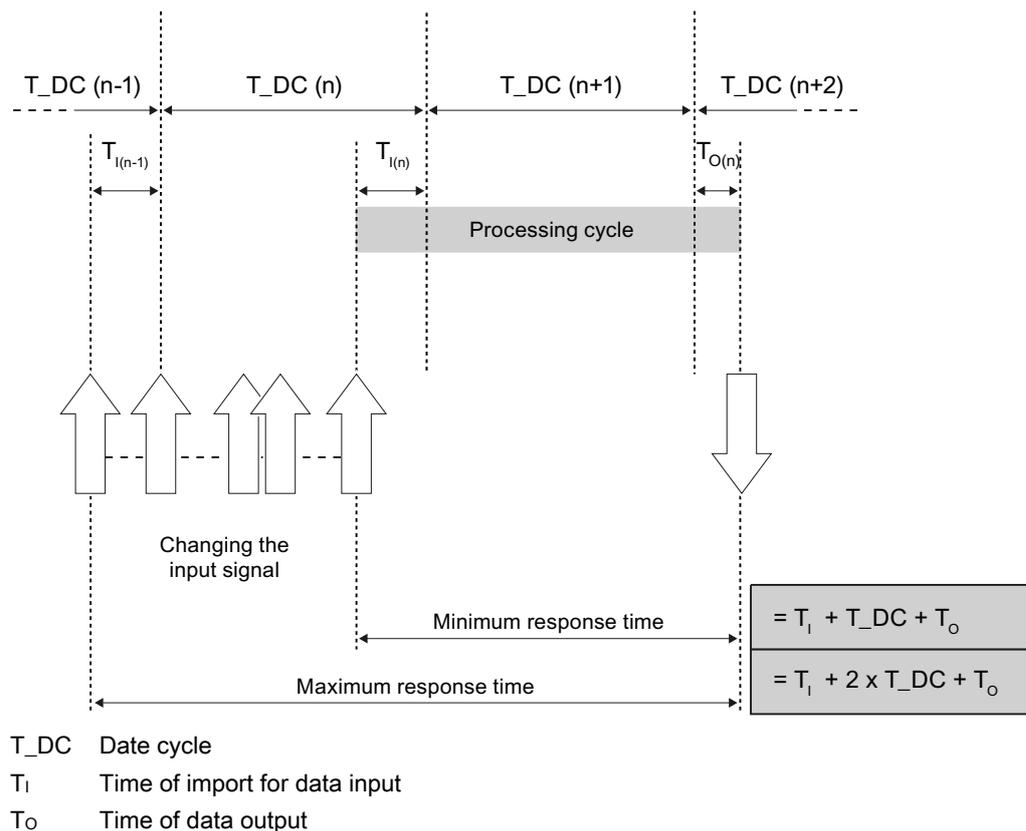
By synchronizing the individual cycles it is possible to read the input data in data cycle "n-1", to transfer and process the data in data cycle "n" and to transfer the calculated output data at the start of data cycle "n+1" and switch it to the "terminals". This results in the actual reaction time of at least "T_I +T_DC +T_O" up to a maximum of "T_I + 2xT_DC + T_O". 2xT_DC results, because the change of the input value could be recognized later by at most one data cycle later due to sampling. The output data is always set at specific time.

With the system property "isochronous mode", the system throughput times of the SIMATIC controller are constant, the SIMATIC controller is strictly deterministic via the PROFINET IO line.

4.9.4 Synchronized execution cycles

4.9.4.1 Synchronized execution cycles

Process reaction in isochronous mode

Process reactions are represented as follows:
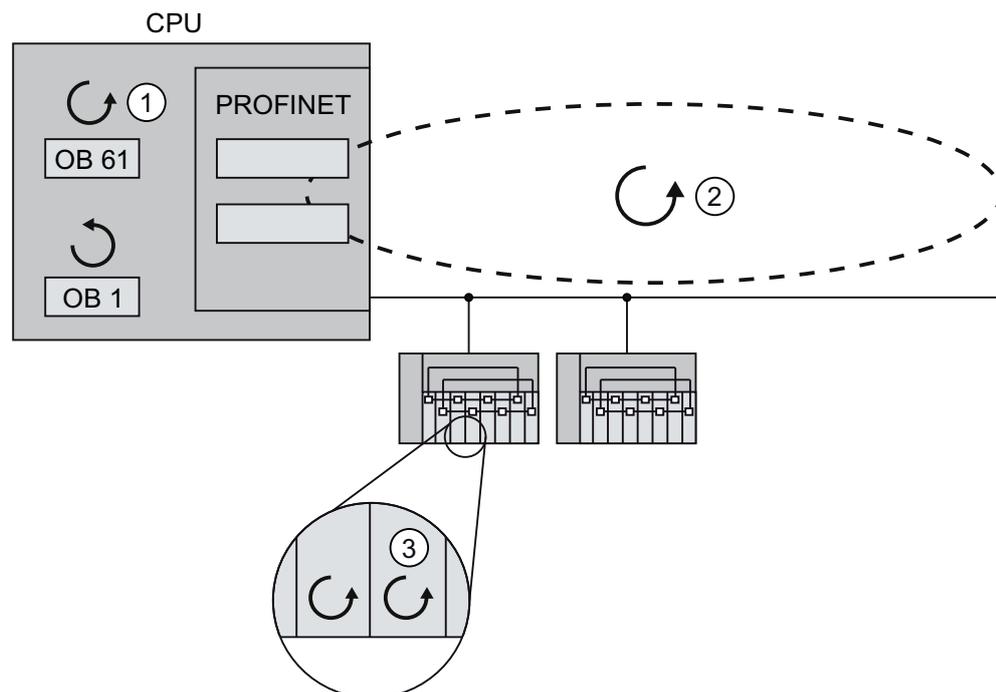
①   Application cycle in the CPU
②   Transfer cycle PROFINET IO:
③   Conversion cycles on the IO devices

In the example above, the response with isochronous mode is represented based on a sample structure with one IO controller and two IO devices. The process data, transfer cycle via PROFINET IO and user program are synchronized with each other to achieve maximum determinism. The input and output data of distributed I/O devices in the system are detected and output simultaneously. The constant PROFINET IO cycle sets the rhythm here.

The OB1 cycle and cyclic interrupts are not integrated in this cycle pattern.

The cycles are synchronized in the user program by executing the synchronous cycle interrupt OB 61 (or OB 61 to OB 64).

Generally all inputs are read in at one time ("flash gun" via the inputs), processed and output to the outputs at one time.

4.9.4.2   The Ti Value

Effect of T_I

The effect of T_I is illustrated by the following figure:

T_DC	Date cycle
T_I	Time for reading in the input data
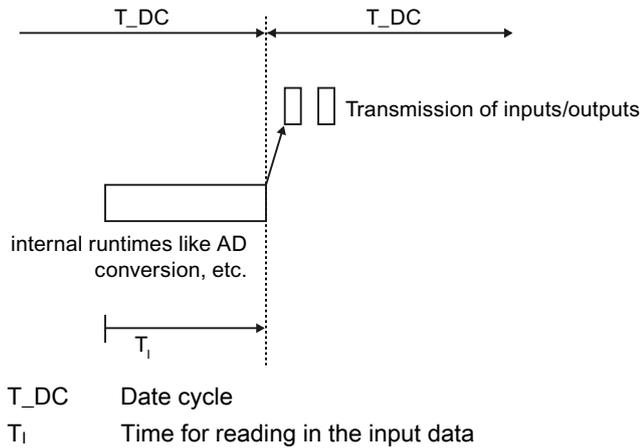
Procedure

So that a consistent state of the inputs can be transferred to the IO controller at the start of the new system clock cycle, the import must be brought forward by the time T_I. The time T_I for a particular input module includes at least the signal conditioning and conversion time on the electronics modules and the time for transfer to the interface module on the IO device backplane bus.

In the plant, the values are imported at the same time because the T_I of the various input modules is set to the same value and this value is greater than or equal to the highest minimum T_I of all input modules. With the default setting, Step 7 makes sure that the smallest possible mutual T_I is set.

4.9.4.3 The User Program OB 6x

Effect

The effect is illustrated by the following figure:

T_DC   System cycle
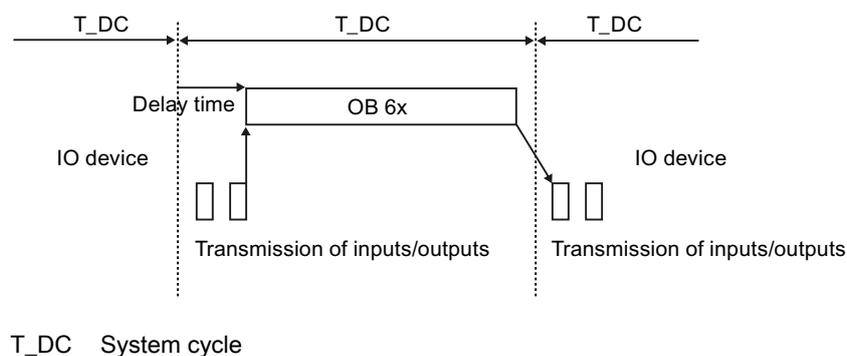
Procedure

STEP 7 initially automatically calculates a suitable value for the delay time. The delay time compensates the transfer time of the inputs of the isochronous IO devices to the IO controller through the PROFINET IO-network. The execution of the OB6x is connected to the system clock cycle and the set delay time. The delay time can, if applicable, be corrected manually as well (see chapter Configuring (Page 145)).

4.9.4.4 The To Value

Effect of T_O

The effect is illustrated by the following figure:
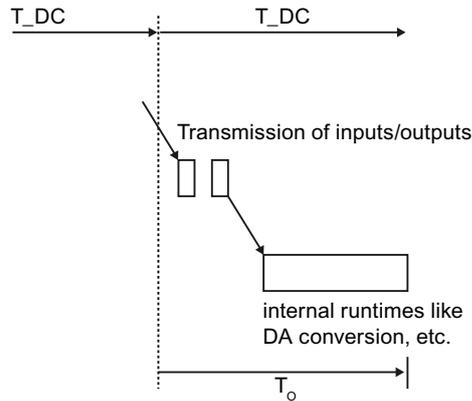
T_DC   System cycle
T_O Time of data output

Procedure

To ensure that a consistent status of the outputs can be transferred to the process at the start of the new system clock cycle, the data is output at the time T_o following the last clock beat. The time T_o records the time of the transfer from the IO-controller to the IO device (through PROFINET IO) for a certain output module and in the IO device, the transfer of the outputs from the interface module to the electronic module (backplane bus)(if applicable, plus time for the digital-analog conversion).

The system makes sure that the values are written simultaneously by setting the T_O of all isochronous output modules to the same value. This value must be greater than or equal to the largest minimal T_O of all isochronous output modules. STEP 7 automatically calculates the shared smallest possible T_O.

4.9.4.5 Isochronous Mode over Several System Clock Cycles

Effect

This figure combines the information from the previous figures.
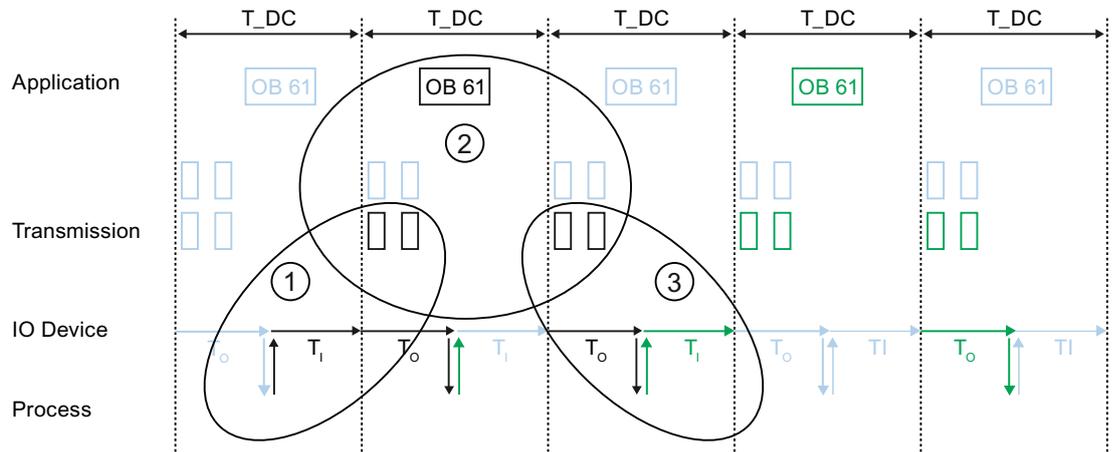
T_DC   System cycle

①   see chapter The Ti Value (Page 138)

②   see chapter The User Program OB 6x (Page 139)

③   see chapter The To Value (Page 140)

Here you can see that T_I, OB 61 and T_O occur after each other. You can also see that T_I, OB61 and T_O occur parallel to each other in one system clock cycle.

4.9.5 Engineering

In the following, you will find out how the isochronous mode is configured and programmed for your application.

4.9.5.1 Basics of Programming

Programming in the synchronous cycle interrupt OBs

The isochronous elements of the program are always programmed in the synchronous-cycle-interrupt OBs OB 61 to OB 64. As the synchronous cycle interrupts are processed at higher priority, only the time-sensitive elements of the program should be processed in OB 6x. The synchronous cycle interrupt is called with a configured delay time.

Accessing isochronous I/O by calling system functions

The updating of the isochronous mode I/O is achieved solely by calling the system functions SFC126 "SYNC_PI" and SFC127 "SYNC_PO" and therefore in the corresponding partial process image. Direct access to the I/O areas returns current values of the process that do not, however, necessarily relate to other values.

The system functions SFC 126 "SYNC_PI" and SFC 127 "SYNC_PO" can only update the process image partition within the permitted time window. The execution window for the possible opening of the SFCs 126/127 stretches from the end of the cyclical data exchange on the PROFINET IO until the point in time before the end of T_DE to which the outputs can still be punctually copied. The data exchange must be started within this time window. If this time window is violated by the processing of system functions SFC 126 or SFC 127, the system functions will indicate this with an associated error message. An image in which the execution window and the corresponding times are displayed can be found in the next chapter.

Note

To prevent inconsistent data being returned for OB6x, you should avoid using SFC14/15 (direct data access) in the isochronous OB.

Note

In order to provide a complete, isochronous operation, you should not open any dataset services for the isochronous operated Io devices and there should be no configured alarms if possible.

Program processing models

Depending on the order in which the system functions SFC126 "SYNC_PI" and SFC 127 "SYNC_PO are opened in OB6x, program execution can be divided into two basic models:

- **IPO** model (read **I**nputs - **P**rocessing - write **O**utputs), CACF = 1
- **IPO** model (read **I**nputs - **P**rocessing - write **O**utputs), CACF > 1

4.9.5.2　　Program Execution According to the IPO Model with Short Time

Label of the IPO-model with application cycle factor = 1

The IP model with application cycle folder = 1 is distinguished by having the processing of the E/A data be completed within a system clock cycle T_DC. The shortest reaction times are achieved with this model.

IPO model with application cycle factor = 1

With the IPO model with application cycle factor = 1, there is a constant processing time of the "input terminal" to the "output terminal" of $T_I + T\_DC + T_O$. $T_I + 2 \times T\_DC + T_O$ can be guaranteed as a process reaction time.
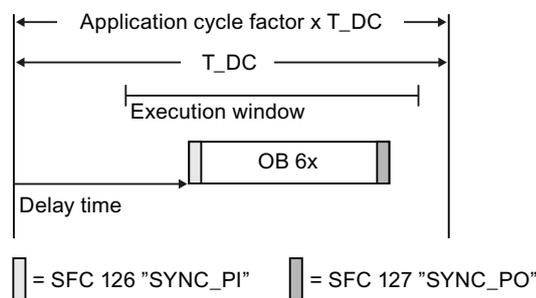
The figure shows the IPO model with the application cycle factor = 1 from acquisition through processing on the CPU to output of the process values. STEP 7 calculates the delay time or you can enter it manually (see chapter Configuring (Page 145)). In this time, the read input data is on its way on PROFINET IO.

The start is the transfer with SFC126 "SYNC_PI" and the end is reached with the SFC127 "SYNC_PO". The delay time is set as a default to the start of the execution window.

SFC 126 "SYNC_PI" and SFC 127 "SYNC_PO" may only be executed in the execution window. Execution must be completed within the data cycle T_DC. When setting the application cycle factor of a value >1, the SFC 126 and SFC 127 must be completed within the first data cycle T_DC; only processing may occur in the following data cycles.

4.9.5.3 Program Execution According to the IPO Model with Long Time

Label of the IPO-model with application cycle factor > 1

The IPO model with application cycle factor > 1 is a IPO model with multiple data cycles T_DC, here we are dealing with an IPO model with an emission delayed by an application cycle (OB6x). The emission occurs before entry for this IPO model.

The SFCs must be opened in the execution window of the first data cycle (only available for application cycle factor > 1). The miscellaneous user program processing in OB6x occurs in the next or through the following data cycles.
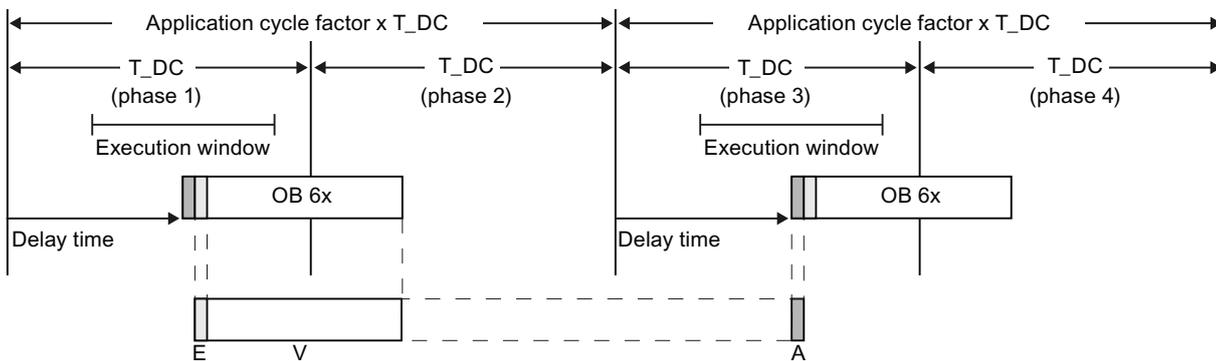
⌷ = SFC 126 "SYNC_PO"   ▮ = SFC 127 "SYNC_PI"

The figure shows the signals of the IPO model with application cycle factor = 2 over time from the acquisition through the processing on the IO controller to the output of the process values. STEP 7 calculates the delay time T_M. In this time, the read input data is on its way on PROFINET IO.

The IPO model with application cycle factor > 1 is particularly ideal for large IO infrastructures with a comprehensive user program in the OB6x. With this model, longer calculation times are possible when processing the input data and obtaining the corresponding output data.

With the IPO model with application cycle factor > 1, there is a constant processing time of the "input terminal" to the "output terminal" of T_I +(application cycle factor + 1) x T_DC + T_O. T_I + (2 x application cycle factor + 1) x T_DC + T_O can be guaranteed as a process reaction time.

4.9.5.4 Configuring

Requirements for creation

First perform the steps below:

1. Create a project with the name "cpu319_isochronous" in the SIMATIC Manager.

2. Insert a new "SIMATIC 300 station".

3. Open the station in HW Config and configure a CPU 319-3 PN/DP with a PROFINET IO system.

4. Add two IM151-3 PN HS to the PROFINET IO system.
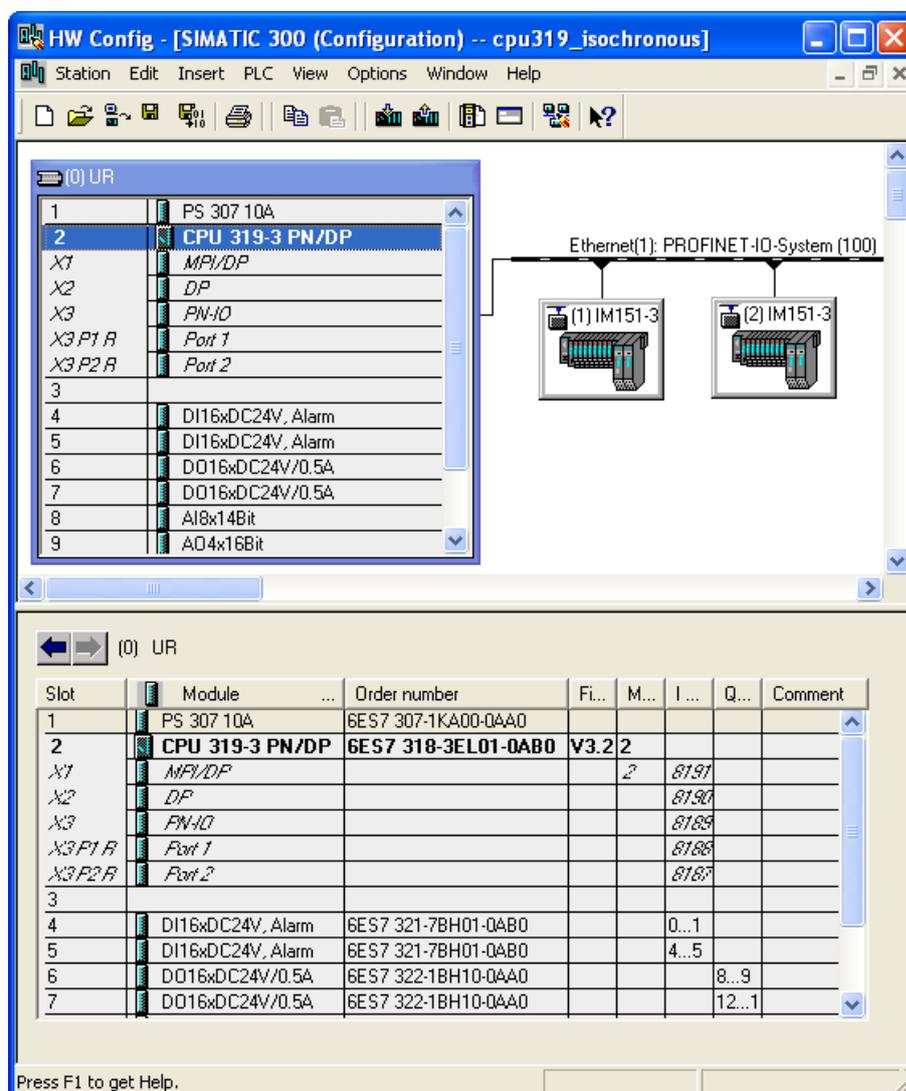
Figure 4-19   Configuring CPU and IM

Synchronization of the CPU

The CPUs must be configured as sync masters, as shown in the following screenshot.

Configure the CPU with the IRT option "high performance"
(see Isochronous real-time (Page 67)).
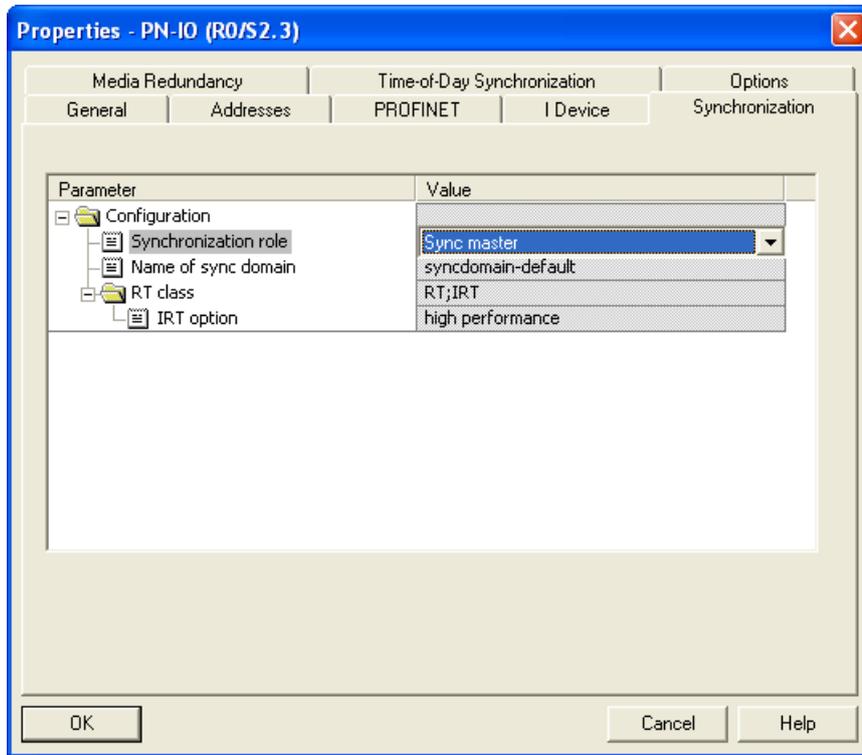
CPU properties

1. Open the "Synchronous Cycle Interrupts" tab in the CPU properties and assign the previously created PROFINET IO system (100) to OB61.
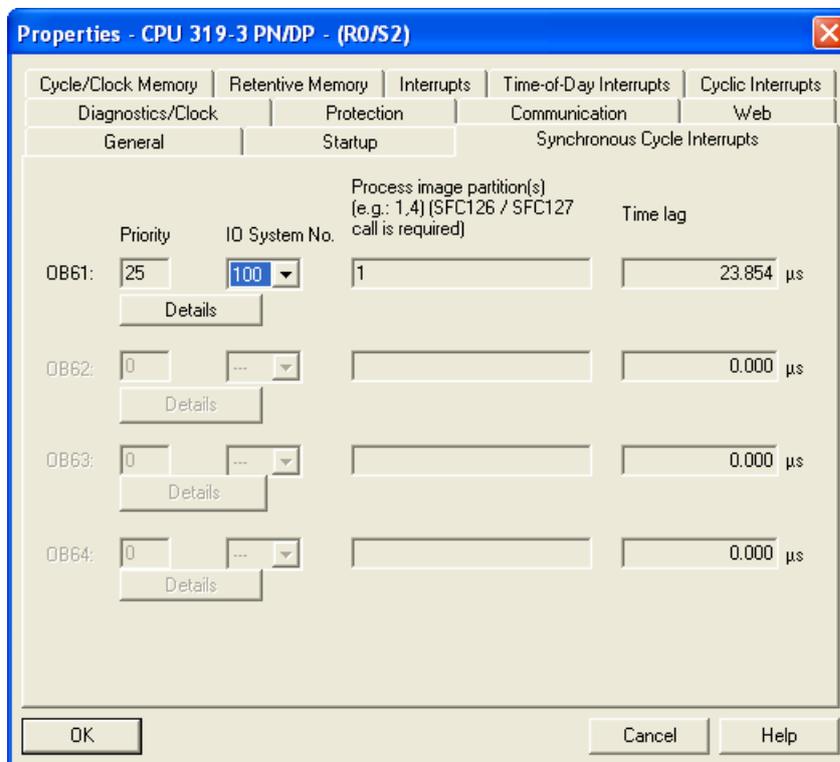
Figure 4-20   CPU synchronous cycle interrupts

2. Open the "Details for OB61" dialog and set the application cycle factor (here factor in short) corresponding with your selected IPO model. In the input field "partial process(es)", set the relevant processes (there is only one for S7-300). Make sure that processes set here cannot be used for central components, PROFIBUS DP slaves and (non-synchonous operated) PROFINET IO devices. In the "Details for OB61" dialog, if applicable, the delay time can be changed manually as well (up to the execution of the OB61).
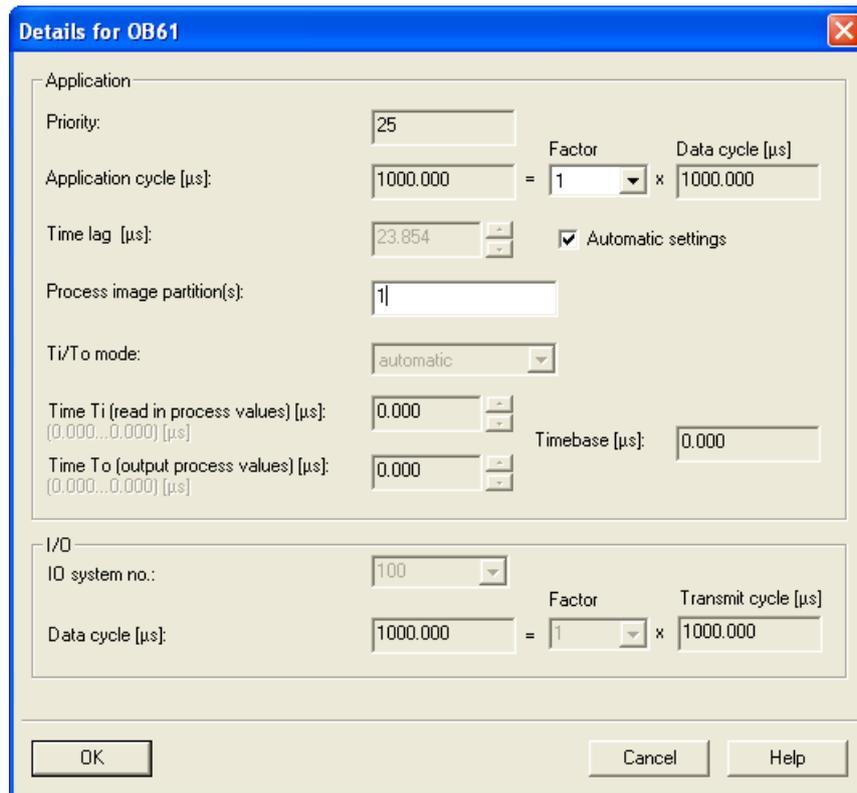
Figure 4-21   Details for OB 61

Synchronization of the IO devices

Set the synchronization individually for the IO devices to be operated in isochronous mode. To do this, double-click on the PN-IO interface and make the following settings there:

1. Open the "Synchronization" tab.

2. Change the synchronization role of the IO device to "Sync slave".

3. Set the RT class "IRT".

4. Select the IRT option "high performance".
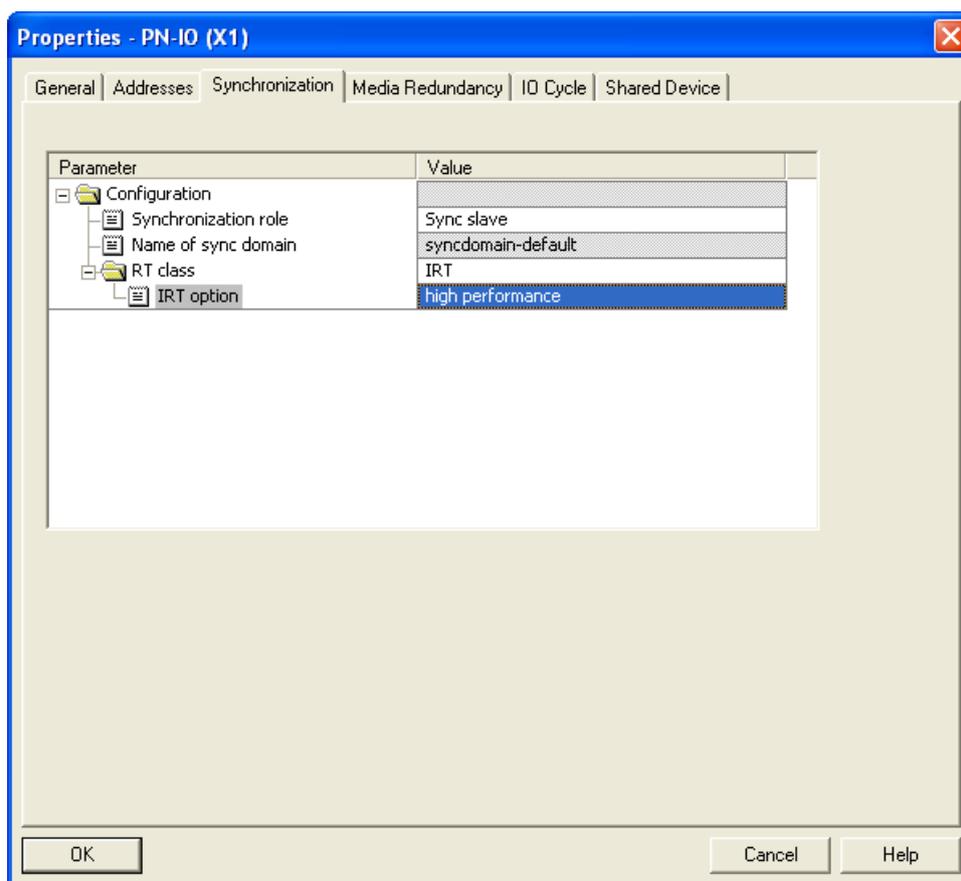
Figure 4-22   IO-device synchronization

Note

Remember that the IRT option "high performance" is possible only with topology configuration.

IO device properties

Open the "IO Cycle" tab of the PN-IO properties dialog and set the following:

1. Section "Update time" "Automatic" mode

2. Section "isochronous mode": IO-device isochronous assignment "OB61".
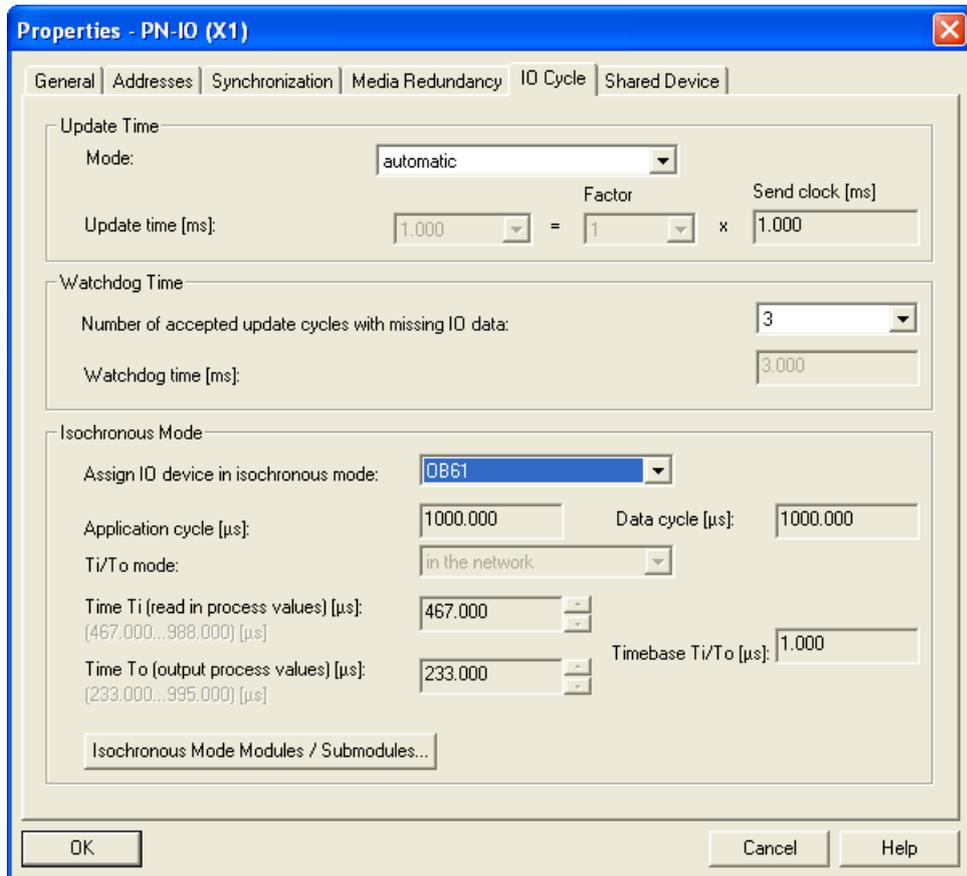
Figure 4-23   IO device

The "Isochronous Mode Modules / Submodules..." button provides you with an overview of the modules operating in isochronous mode. The dialog also allows you to enable / disable operation in isochronous mode for individual modules.
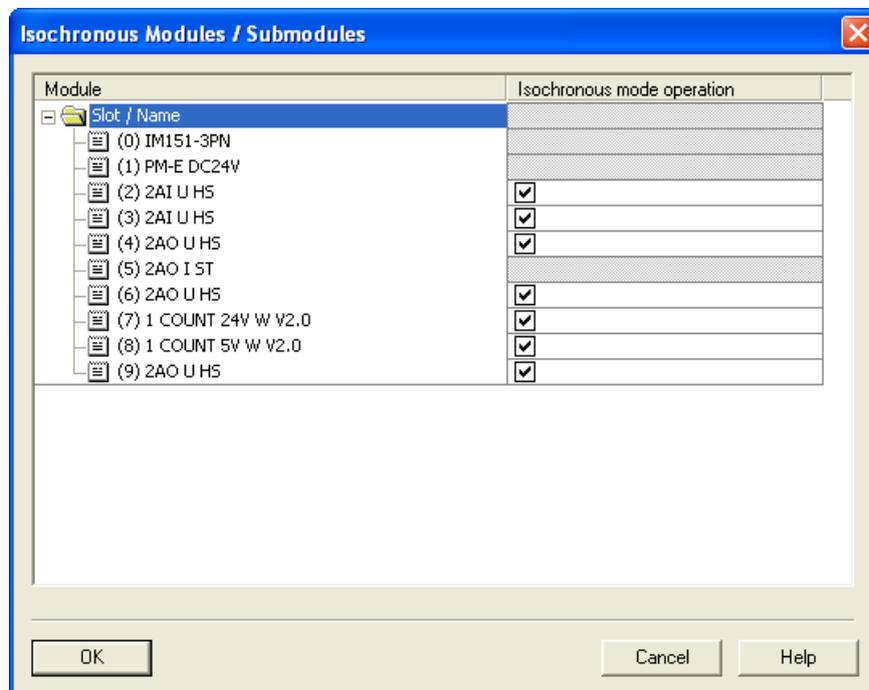
Figure 4-24   Isochronous mode module

Overview

If you open **Edit > PROFINET IO > Isochronous Mode** in HW Config, you obtain an overview of the entire isochronous mode project.
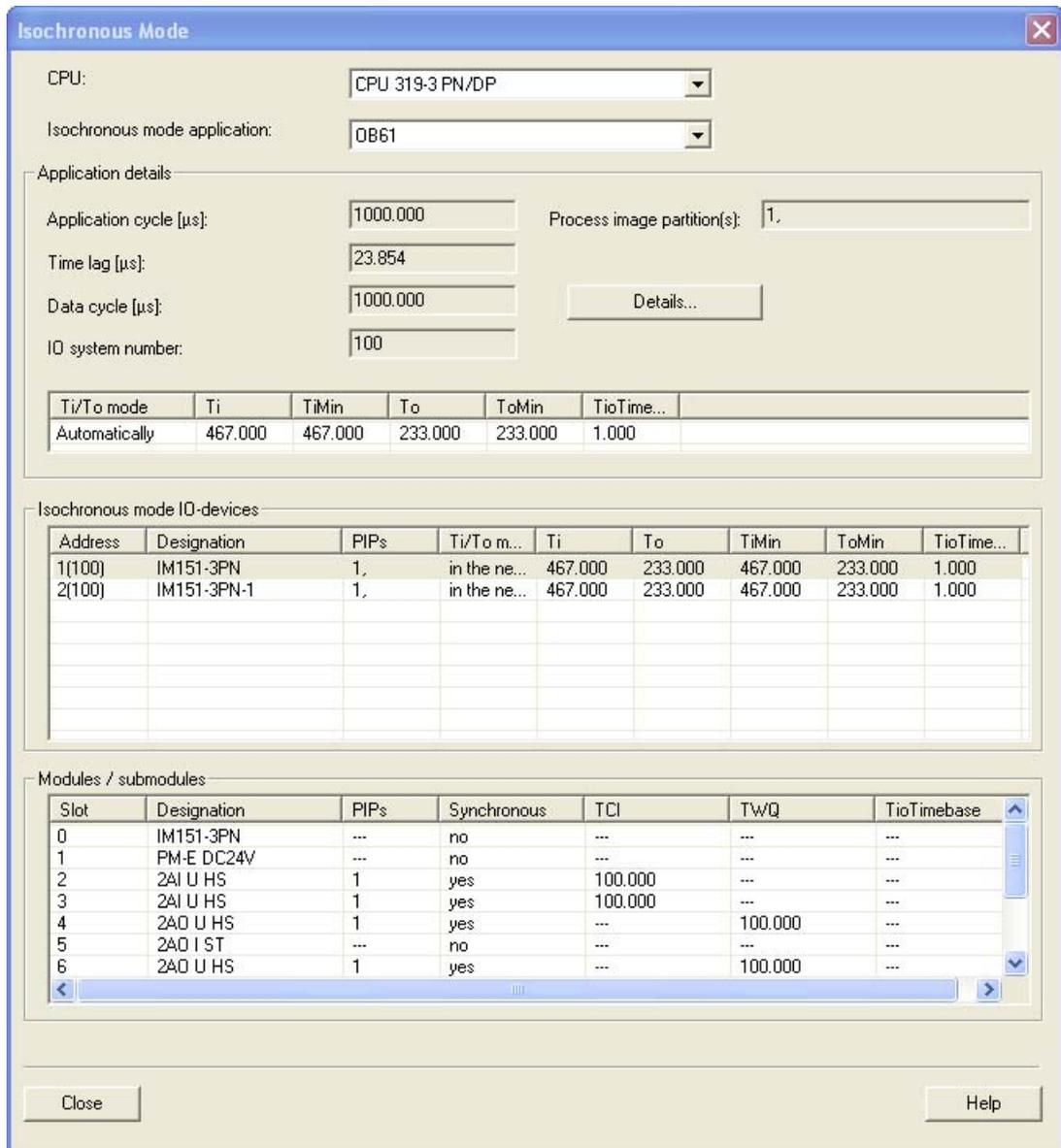
Figure 4-25   Overview

Automatic Timers Command

In this dialog, you can see the times set by STEP 7. You have the option of setting the times manually. If you want to do this, follow the steps described in the next section.

How do I stop times being assigned automatically

If an inadequate T_I or T_O results from the automatic calculation, you must take this component out of the automatic calculation and calculate T_I or T_O individually.

4.9.6 Diagnostics and interrupt characteristics

Diagnostics and interrupt characteristics

To synchronize clock cycles, you can use the diagnostics and interrupt functions of STEP 7. These reduce down times and simplify localization and elimination of problems.

Below, you will find the events for diagnostics and interrupt functions and remedies for the problem.

Diagnostics in detail

Event	Cause of the error	Remedy
OB 80 comes and OB 6x reports how many calls it has missed.	OB 6x takes too long	• Shorten OB 6x • Increase the data cycle • Set a shorter delay time
SFC126/127 are not opened or edited in the OB6x execution window.	• SFC 126/127 report "too early". • SFC 126/127 report "too late".	• With the "too early" message: Increase the delay time • If the "too late" message appears: Adjust program or use CACF > 1
Diagnostic interrupts	Module reports a module fault, etc.	The module changes to STOP or OB 82 (if it exists) is opened.
I/O access error	Input or output module does not respond.	The module changes to STOP or OB 122 (if it exists) is opened.
Rack fault	Station is not accessible.	The module changes to STOP or OB 86 (if it exists) is opened.
The IO controller is sync slave and is not synchronized.	If the GC_Viol bit is set to "1" in OB 6x ...	... you will need to turn on the SYNC master.
IO device is not synchronized with the OB6x (failure of the SyncMaster); this leads to a station failure	• For the IO device, "station failure" is displayed. • The channel error "sync discrepancy" is mapped to Sync Violation on the IO Controller.	The module changes to STOP or OB 86 (if it exists) is opened.

See also:

STEP 7 online help

4.10 PROFIenergy

Save energy with PROFIenergy

PROFINET-based data interface for switching off consumers centrally and with full coordination during idle times regardless of the manufacturer or device type. Result: process should only be provided with the energy that is absolutely required. The majority of the energy is saved by the process itself, the PROFINET device itself only contributes a few watts of savings potential.

Basic information

Turning off the PROFINET device or the power module occurs through special commands in the user program of the PROFINET IO Controller. No additional hardware is needed, the PROFIenergy commands are directly interpreted by the PROFINET devices.

Principle of operation

At the beginning and end of breaks, the system manager enables or disables the break function of the system; then the IO-controller sends the PROFIenergy command "Start_Pause" / "End_Pause" to the PROFINET device. The device interprets the contents of the PROFIenergy command and turns on / off.

Through other PROFIenergy functions, device information can be accessed during the breaks. The user can use this information in order to punctually transfer the "Start_Pause" / "End_Pause" command.

PROFIenergy blocks for IO Controller

In order to control and monitor the PROFIenergy functions, two function blocks (FBs) are required.

With the block **FB 815 "PE_START_END"**, the standby of the PROFINET device is enabled or disabled in the easiest manner. This occurs through an incoming or outgoing edge in the FB. The FB 815 offers a simple interface for the realization of the PROFInergy command "Start_Pause" and "End_Pause".

All PROFIenergy commands, including "Start_Pause" and "End_Pause", can be transmitted using the block **FB 816 "PE_CMD"**. With the other commands, for example, the current status of the PROFINET device or the behavior during the breaks can be inquired. The FB 816 allows for the comfortable handling of all PROFIenergy functions.

PROFIenergy blocks for I-devices

With the block **FB 817 "PE_I_DEV"**, PROFIenergy can also be realized on I-devices. The block receives PROFIenergy commands on the I-device and forwards these to the user program for processing. After the processing of the command through the user program, it recalls the FB 817 in order to send the receipt to the IO controller. For these answers, the user is provided a help block for each command, which provides the FB 817 with the answer data.

The blocks and an application example can be found online in the service and support portal: Service and support - PROFIenergy (http://support.automation.siemens.com/WW/view/en/41986454)

Configuration and programming

The functions can be comfortably integrated into existing systems. No configuration is required for the use of PROFIenergy. However, amendments to the user program are required:

● Before the "Start_Pause" command, the user must make sure that the system is brought into a state that is safe and suitable for a pause.

● A time expiration control for the beginning of the break for the device and for the punctual restarting of the node on break must be programmed (depending on the required switch on times that the respective PROFINET device demands).

● The error messages of the FB must be evaluated and the corresponding required reaction must be programmed (for example, cancellation or continuation of further commands to the lower-level PROFINET devices).

4.11 Media redundancy

4.11.1 Options of media redundancy

To increase the network availability of an Industrial Ethernet network,
you can connect a linear bus topology to a ring topology.

Media redundancy in ring topologies

Nodes in a ring topology can be IO devices, IO controllers, external switches and/or the
integrated switched of communications modules. All nodes of the ring must support the
"Media redundancy" function.

To set up a ring topology with media redundancy, you bring together the two free ends of a
linear bus topology in one device. Closing the linear bus topology to form a ring is achieved
with two ports (ring ports) of a device in the ring. At least one device of the ring takes over
the role of the redundancy manager. All other devices in the ring are redundancy clients.

①   Redundancy manager
②   Test telegrams
③   Redundancy clients
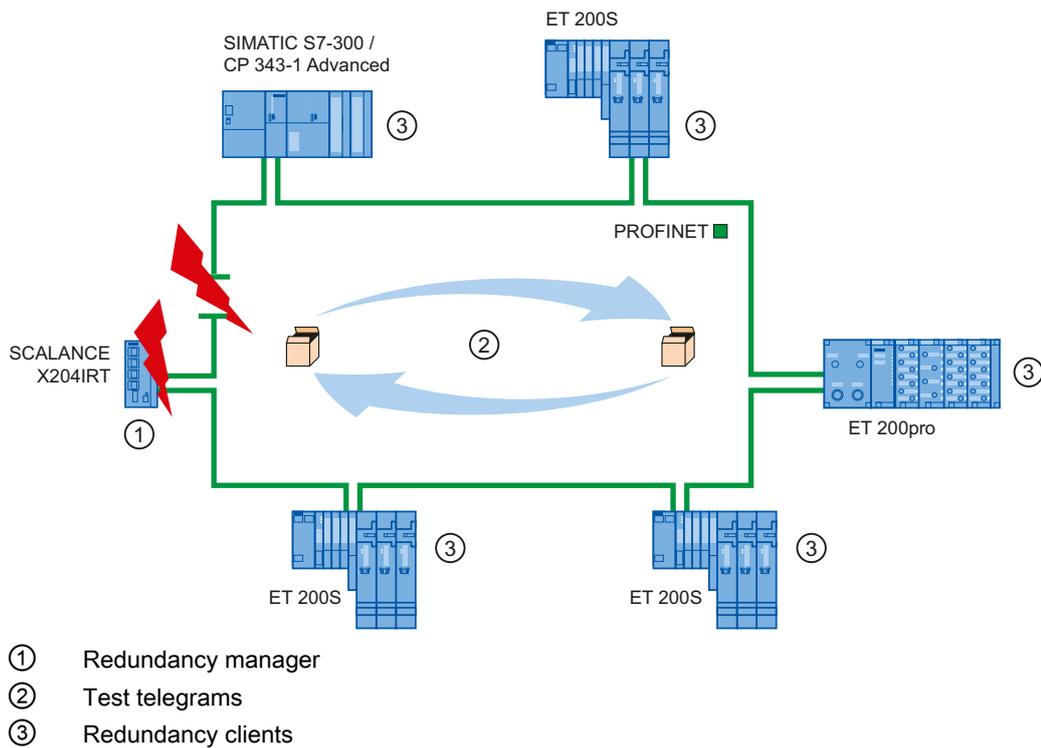
Figure 4-26   Media redundancy in ring topology

The two ring ports of a device are the ports that establish the connection to its two
neighboring devices in the ring topology. The ring ports are selected and set in the
configuration of the relevant device (is also preset, if applicable).

How media redundancy works in a ring topology

The data paths between the individual devices are automatically reconfigured if the ring is interrupted at any point. The devices are available again after reconfiguration.

In the redundancy manager, one of the 2 ring ports are blocked for uninterrupted network operation for normal communication so that no data telegrams are circulated. In terms of data transmission, the ring topology is a linear bus topology. The redundancy manager monitors the ring for interruptions. It does this by sending test frames from both ring port 1 and ring port 2. The test frames run through the ring in both directions until they arrive at the other ring port of the redundancy manager.

An interruption of the ring can be caused by loss of the connection between two devices or by failure of a device in the ring.

If the test frames of the redundancy manager no longer arrive at the other ring port, the redundancy manager connects its two ring ports. This substitute path once again restores a functioning connection between all remaining devices in the form of a linear bus topology.

The time between the ring interruption and restoration of a functional linear topology is known as the reconfiguration time.

As soon as the interruption is eliminated, the original transmission paths are established again, the two ring ports of the redundancy manager are disconnected and the redundancy clients informed of the change. The redundancy clients then use the new paths to the other devices.

Media redundancy methods

The standard method of media redundancy in SIMATIC is MRP (Media Redundancy Protocol) with a typical reconfiguration time of 200 ms. Up to 50 devices can participate per ring.

In addition, there is also the real-time capable media redundancy procedure MRPD (Media Redundancy with Planned Duplication).

4.11.2 Media Redundancy Protocol (MRP)

Media Redundancy Protocol (MRP)

The Media Redundancy Protocol (MRP) procedure operates in compliance with the Media Redundancy Protocol (MRP), which is specified in the directive IEC 61158 Type 10 "PROFINET".

The reconfiguration time after an interruption of the ring is typically 200 ms.

Requirements

The following requirements must be met for problem-free operation with the media redundancy protocol MRP:

- The ring in which you want to use MRP may only consist of devices that support this function.

- "MRP" must be activated for all devices in the ring.

- All devices must be interconnected via their ring ports.

- The ring can contain a maximum of 50 devices.

- The connection setting (transmission medium / duplex) must be set to "full duplex" and at least 100 Mbps for all ring ports. Otherwise there may be a loss of data traffic.

  To do this, set all the ports involved in the ring to "Automatic settings" in the "Options" tab of the properties dialog during STEP 7 configuration.

Topology

The following schematic shows a possible topology for devices in a MPR ring. The devices inside the white oval are in the redundancy domain.

Example of a ring topology with the MRP media redundancy protocol
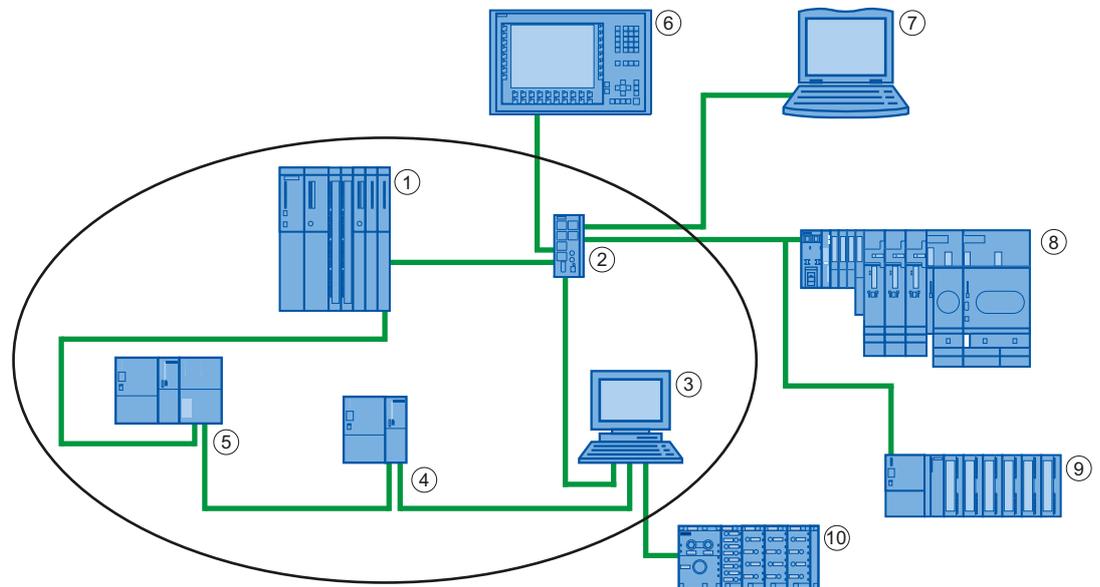
①	S7-400 with CP 443-1 advanced	⑥	HMI station
②	Switch SCALANCE X206-1	⑦	Programming device/PC
③	PC with CP 1616	⑧	ET 200S
④	S7-300	⑨	ET 200M
⑤	S7-300 with CP 343-1 advanced	⑩	ET 200pro

Figure 4-27   Example of a ring topology with the MRP media redundancy protocol

The following rules apply to a ring topology with media redundancy using MRP:

● All devices in the ring belong to the same redundancy domain.

● At least one device in the ring acts as redundancy manager.

● All other devices in the ring are redundancy clients.

Non MRP-compliant devices can, for example, be connected to the ring via a SCALANCE X switch of via a PC with a CP 1616.

Boundary conditions

MRP and RT

RT operation is possible with the use of MRP.

Note

The RT communication is disrupted (station failure) if the reconfiguration time of the ring is greater than the selected response monitoring time of the IO device. That is why you should select the response monitoring time of the IO-device in a large enough manner.

MRP and RT

The IRT operation together with MRP is not possible.

MRP and TCP/IP (TSEND, HTTP, ...)

The TCP/IP communication with MRP is possible, because lost data packages are resent.

MRP and prioritized startup

If you configure MRP in a ring, you cannot use the "prioritized startup" function in PROFINET applications on the devices involved.

If you want to use the "prioritized startup" function, then you must disable MRP in the configuration (the device may also not be part of the ring).

In the STEP 7 configuration, properties dialog of the PROFINET interface >
"Media Redundancy" tab > "MRP configuration" box, set the role to "Not node in the ring" in the "mrpdomain1" domain.
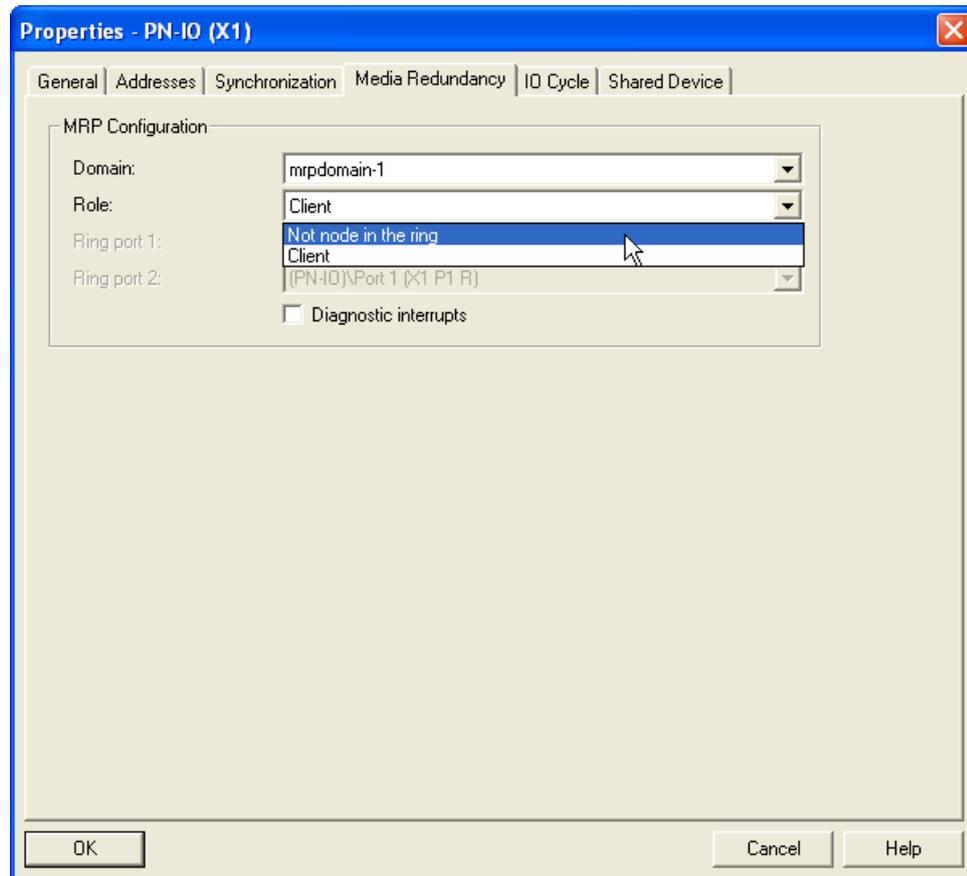
Figure 4-28   "Media redundancy" Dialog Field

MRP to PROFINET devices with more than two ports

If you are operating a PROFINET device with more than two ports in a ring, then you should avoid the feed-in of sync frames into the ring by placing a sync boundary (on the ports that are not in the ring). The settings for sync boundaries can be executed in the port properties in the "Options" tab.

4.11.3   Media Redundancy with Planned Duplication (MRPD)

MRP add-on "Media Redundancy with Planned Duplication" (MRPD)

If media redundancy is to be achieved with short update times (together with IRT), you must use the MRP add-on "Media Redundancy with Planned Duplication" (MRPD).

MRPD is based on IRT with "high performance" and MRP. To realize media redundancy with short update times, the PROFINET devices participating in the ring send their data in both directions. The devices receive this data on both ring ports, eliminating the ring's reconfiguration time. As with MRP, the redundancy manger prevents circling data frames.

4.11.4   Configuring media redundancy under PROFINET IO

Requirements for media redundancy with MRP

- The involved components must support the media redundancy protocol (MRP).
- No IRT communication is configured.

Requirements for media redundancy with MRPD

- The components involved must support Media Redundancy with Planned Duplication (MRPD).
- IRT with "high performance" is configured for all associated components.

Proceed as follows

There are three options for configuring media redundancy:

- Via the Domain Management (automatic) using the "Auto-Config" button.
- Via the Domain Management (manual); in this case MRP domains can also be managed.
- Via the PN-IO interfaces of the affected PROFINET devices.

Media redundancy configuration via the Domain Management (automatic):

1. Generate a ring via corresponding port interconnections (for example, in the topology editor).
2. Right-click on the PROFINET IO system and select "PROFINET IO Domain Management..." from the shortcut menu.
3. Navigate to the "MRP domain" tab.
4. Select the "Ring interconnections" check box in the "Nodes" section.
5. From the upper list, select the ring that has just been generating via the port interconnection. In the lower list, you can check that the selection is correct.
6. Click on the "Auto-Config" button.
7. The MRP configuration is generated automatically.

Media redundancy configuration via the Domain Management (manual):

1. Right-click on the PROFINET IO system and select "PROFINET IO Domain Management..." from the shortcut menu.
2. Navigate to the "MRP domain" tab.
3. In the Nodes section, all existing nodes in the project can be selected, sorted by station, with regard to the use of media redundancy, and configured. Multiple stations/devices can be selected by holding down the Ctrl key while clicking and jointly configured via the "Edit..." button.

For information on the setting options, refer to the Setting options section below.

Media redundancy configuration via the interfaces of the affected PROFINET devices:

Media redundancy must be configured for all PROFINET devices that are to be operated in media redundant mode:

1. Double-click on the PROFINET IO interface of the device to be configured.

2. Navigate to the "Media redundancy" tab and perform the configuration.
   For information on the setting options, refer to the following section.

Setting options in the "Media redundancy" tab

Domain

All devices that are to be configured in a ring with MRP must belong to the same redundancy domain. A device cannot belong to more than one redundancy domain. From the drop-down list box, select the same domain (usually "mrpdomain-1") for all devices of your ring.

The MRP settings are even effective after the device is restarted, or after a power failure and restart, in other words they are stored retentively.

Role

Depending on the device used, the roles "Manager", "Manager (Auto)", "Client" and "Not node in the ring" are available.

Rules:

- A ring must have at least one device with the role "Manager (Auto)".

- A ring must have precisely one device with the role "Manager". No additional devices with the role "Manager" or "Manager (Auto)" are permissible. All other devices may only have the role "Client" or "Not node in the ring".

Ring port 1 / Ring port 2

Select one at a time those ports you want to configure as ring port 1 or ring port 2. The drop-down list box shows the selection of possible ports for each device type. If the ports are set at the factory, then the fields are unavailable.

Diagnostic interrupts

Mark the option "Diagnostics interrupts" if diagnostics interrupts should be issued regarding the MRP status in the local CPU. The following diagnostic interrupts can be configured:

- Wiring or port error

  Diagnostic interrupts will be generated for the following errors in the ring ports:

  – A neighbor of the ring port does not support MRP

  – A ring port is connected to a non-ring port

  – A ring port is connected to the ring port of another MRP domain.

- Interruption / return (only redundancy manager)

  If the ring is interrupted and the original configuration is returned, diagnostics interrupts will be generated. If both of these interrupts occur within 0.2 seconds, this indicates an interruption of the ring.

NOTICE
To assure error-free operation when a 3rd party device is used as redundancy manager in a ring, you must assign the fixed role of "Client" to all other devices in the ring before you close the ring. Otherwise circulating data frames and network failure could occur.

4.12 System redundancy

4.12.1 Introduction

Why fault-tolerant automation systems?

The purpose of using fault-tolerant automation systems is to reduce production downtimes, regardless of whether the failures are caused by an error/fault or are due to maintenance work.

The higher the costs of production stops, the greater the need to use a fault-tolerant system. The generally higher investment costs of fault-tolerant systems are soon recovered since production stops are avoided.

Fault-tolerant automation systems in SIMATIC (S7–400H) consist of two redundantly configured subsystems that are synchronized via fiber-optic cables.

Both subsystems create a fault-tolerant automation system operating with a two-channel (1-out-of-2) structure based on the "active redundancy" principle.

What does active redundancy mean?

Active redundancy means that all redundant resources are constantly in operation and simultaneously involved in the execution of the control task.

For the S7-400H this means that the user programs in both CPUs are identical and executed synchronously by the CPUs.

Synchronizing the subsystems

The master and reserve CPUs are linked by fiber-optic cables.
Both CPUs maintain event-synchronous program execution via this connection.

Subsystem (CPU0)   Subsystem (CPU1)
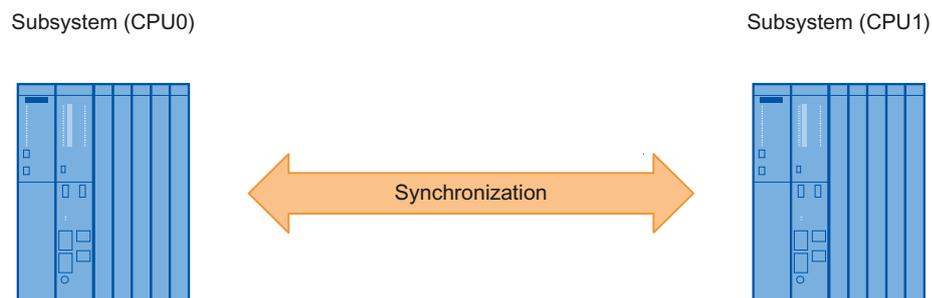

Synchronization

Figure 4-29   Synchronizing the subsystems

Synchronization is performed automatically by the operating system and has no effect on the user program. You create your program in the same way as for standard S7-400 CPUs.

4.12.2 Use of I/O devices on the PN/IO interface, system redundancy

In the case of the system-redundancy connection of IO devices via PROFINET, a communication connection (application relation) exists between each IO device and each of the two H CPUs. This communication connection can be established via any topological interconnection; it is therefore not possible to recognize from a system's topology whether an IO device is connected in system-redundancy mode.

In addition to system-redundancy mode, IO devices can also be operated as what are know as "one-sided devices". In this case only one of the two CPUs establishes a communication connection to the IO device. However, the one-sided connection has the disadvantage that the IO device will fail if there is a failure of the CPU to which the communication connection is established.

PN/IO with redundant system

The following figures shows a configuration with two IO devices connected in system-redundant mode. This topology is especially advantageous. The complete system can continue to operate if there is a line interruption regardless of where this occurs. One of the two communication connections of the IO device is maintained at all times. The redundant IO devices then function the same as one-sided IO devices.

① S7-400H system
② Redundant IO device
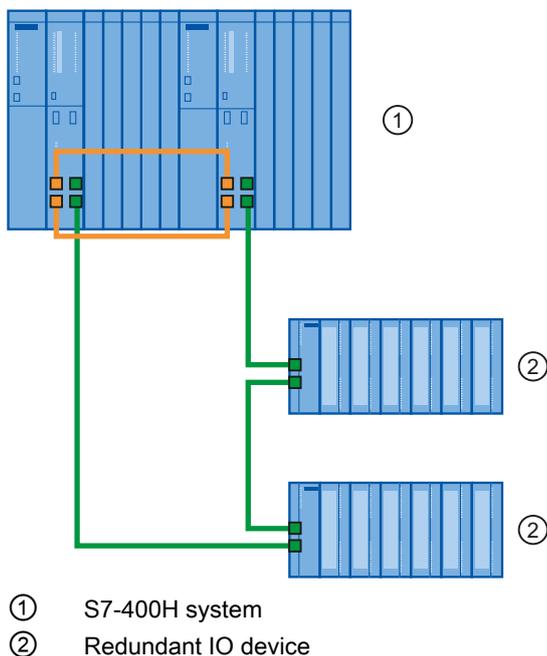
Figure 4-30   S7-400 H system with redundant IO devices

PN/IO with one-sided IO devices

The following figure shows a possible topological configuration with a switch. Two IO devices are connected one-sided (not redundant), the three other IO devices are connected as redundant system.


①	S7-400H system
②	SCALANCE (e.g. X400)
③	Redundant IO device
④	One-sided IO device
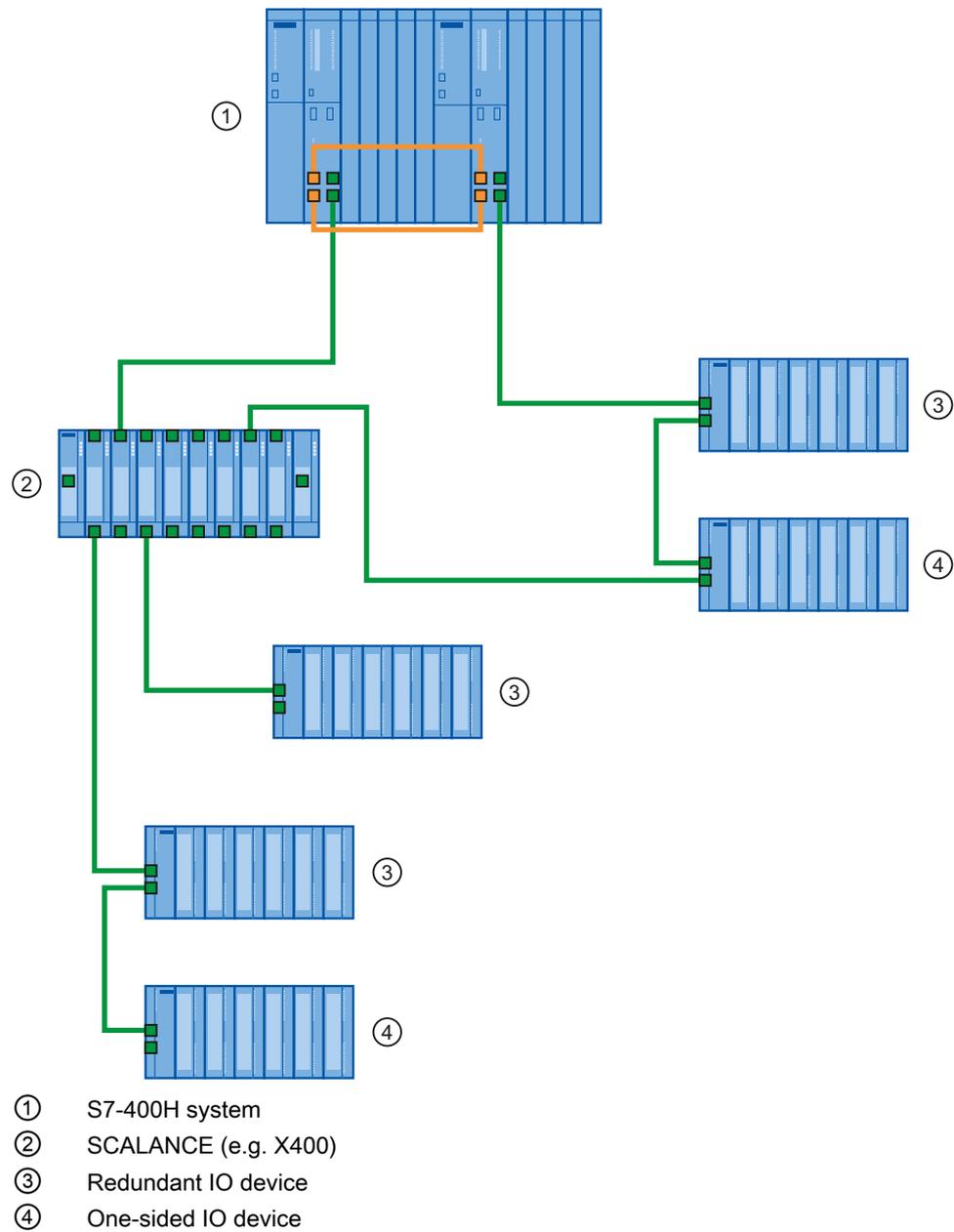
Figure 4-31   S7-400 H system with redundant and one-sided IO devices

Maximum number of IO devices

Altogether, you can connect a maximum of 256 IO devices to the two integrated PN/IO interfaces. The station numbers are distributed uniquely across both PN/IO interfaces and are between 1 and 256.

4.12.3   Configuring

Configuring system redundancy with PROFINET IO

Requirements

- The associated components support the PROFINET system redundancy.

- No IRT communication is configured.

- The IO systems of the H system are located in the same network.

In the following example you configure a redundant PROFINET configuration system with redundant IO devices as in the previous section in the figure "S7-400 H system with redundant IO devices"

PROFIBUS components are not used. Basic information on configuring H-systems can be found in the "High-availability systems S7-400H " manual.

Proceed as follows

Create a new H station in the SIMATIC Manager and open "HW Config" for the station.

1. Insert a 400 rack (such as UR2-H) for redundant controllers.

2. Insert a 400-H PN/DP CPU (for example, CPU 414-5 H PN/DP)

3. Network the Ethernet interface as usual and set the IP parameters.

4. Configure a power supply module and the H-Sync module.

5. Copy the station created: To do this select the station and then select **Edit > Copy** and **Edit > Insert**

6. Configure the redundant ET200M modules (for example, IM153-4 PN HF V4.0) by dragging the IO devices as usual to one of the two IO systems. By default, the modules are connected redundantly (to both PROFINET phase elements).
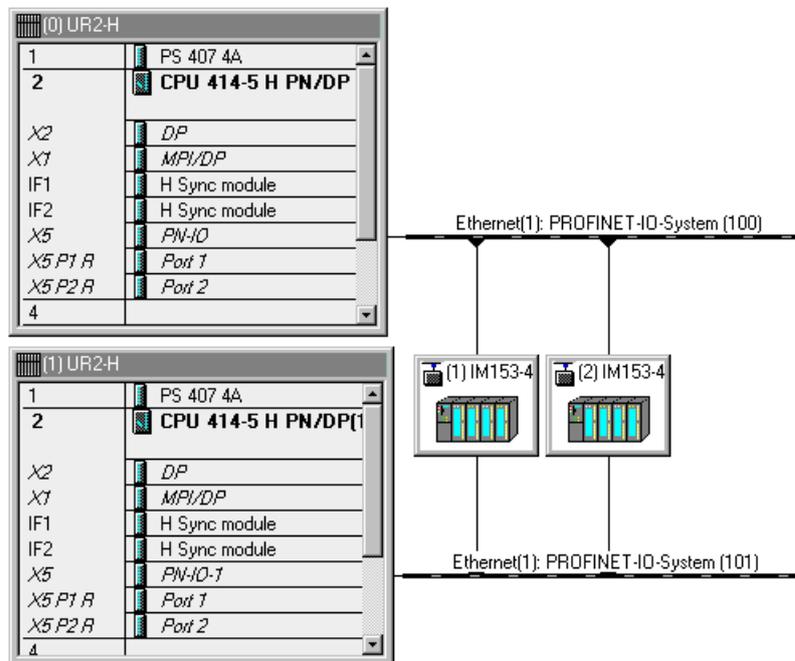

Figure 4-32   Redundantly connected ET200M modules in HW Config.

You have two options for connecting modules as one-sided IO devices:

- Configure a redundant module as described above and navigate to the "Redundancy" tab of the module properties. The check box there allows you to assign the IO device to only one IO system and thus to only one CPU.
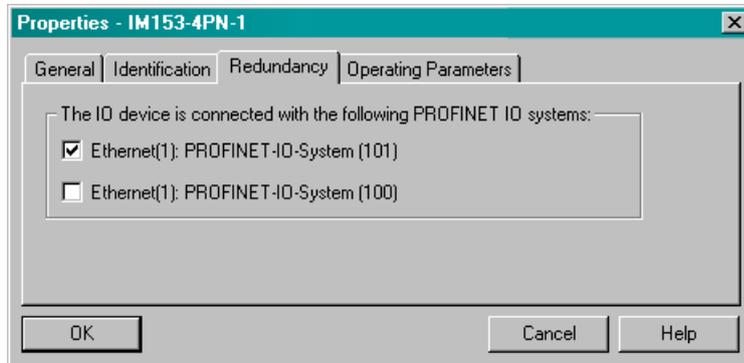
Figure 4-33   "Redundancy" tab in the module properties

- Configure the specific standard IO devices (for example, IM153-4 PN ST V4.0) on the required IO system.
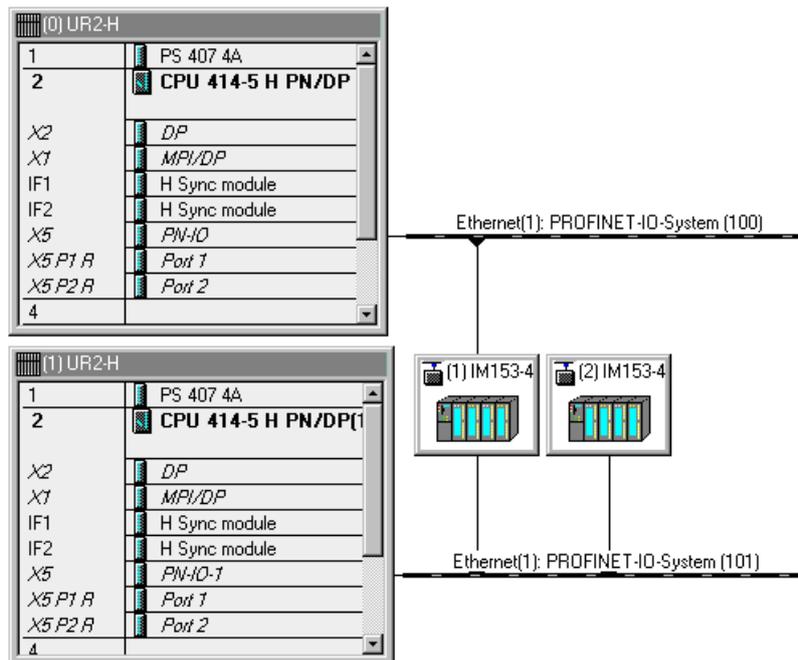
Figure 4-34   One-sided connected ET200M modules

Note

H systems and separated subnets

IO device are only integrated redundantly if the two PROFINET IO systems of the H system are located in the same subnet. Each CPU can, alternatively, also be networked with a different subnet. In this case the IO devices are always connected only one-sided.

4.12.4 Possible topologies

Topology

In PROFINET, you can also combine system redundancy with other PROFINET functions.

System redundancy with media redundancy

① S7-400H system
② SCALANCE X400 (one-sided IO devices)
③ ET200M (one-sided/system-redundant IO devices)
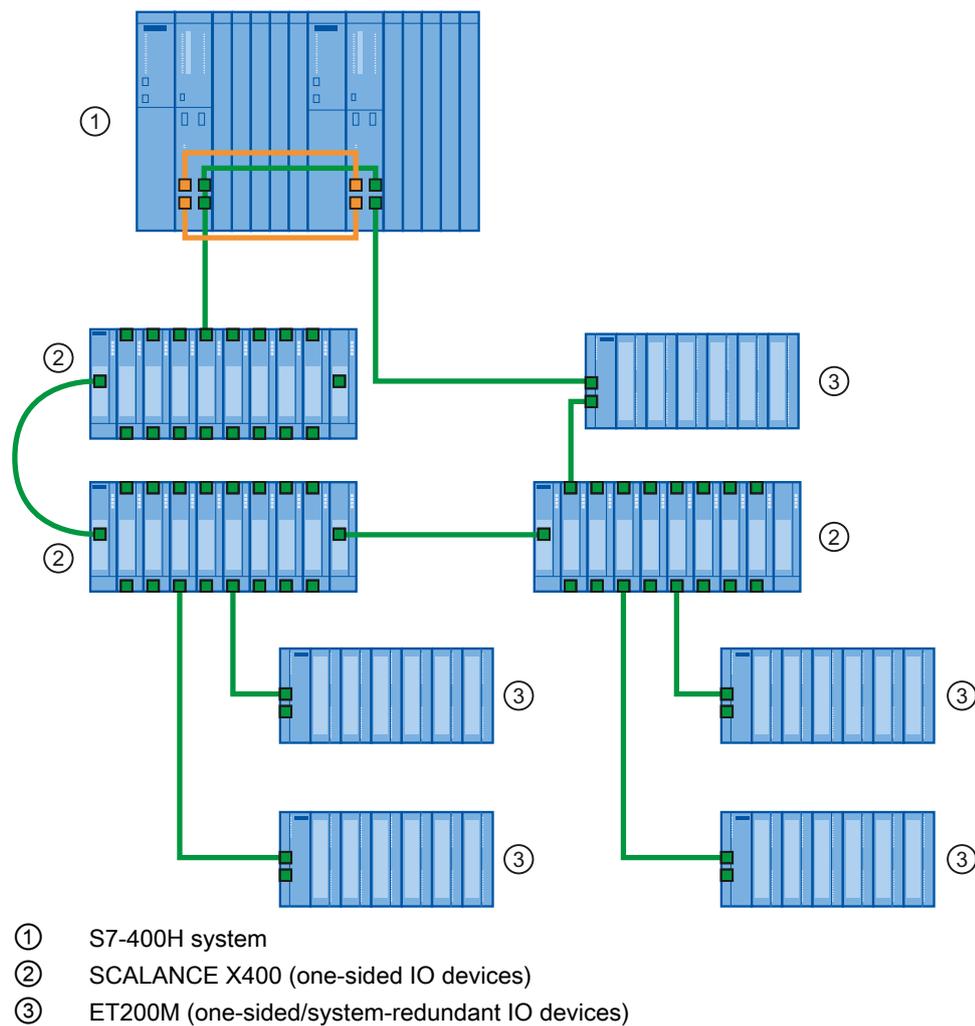
Figure 4-35   Example configuration of system redundancy with MRP

Note

The RT communication is disrupted (station failure) if the reconfiguration time of the ring is greater than the selected response monitoring time of the IO device. That is why you should select the response monitoring time of the IO-device in a large enough manner. This applies also to MRP configured IO devices outside of the ring.

System redundancy with W-LAN
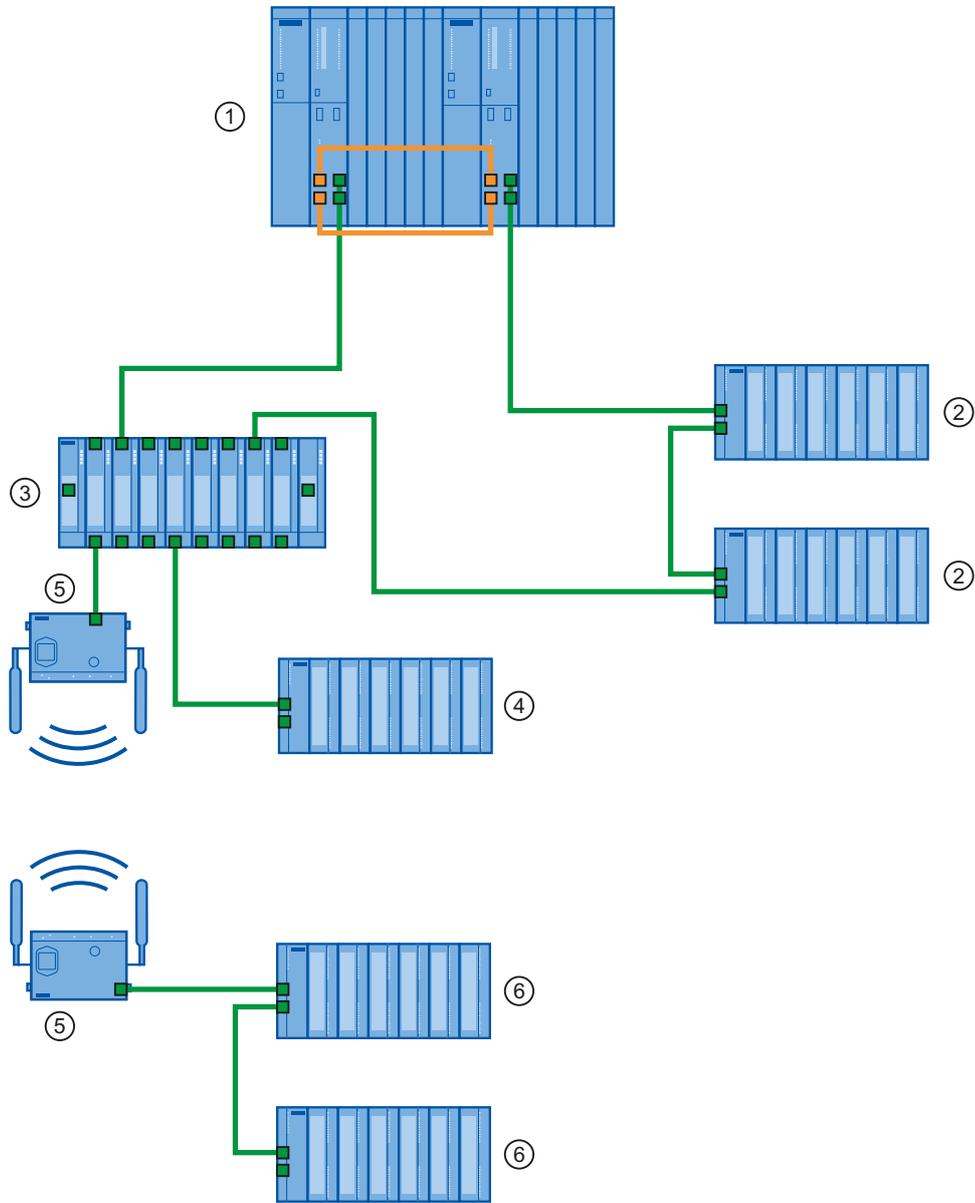
①   S7-400H system

②   Redundant I/O device ET 200M

③   SCALANCE X400

④   One-sided I/O device ET 200M

⑤   SCALANCE W

⑥   One-sided IO device ET 200M, connected by W-LAN

Figure 4-36   Example configuration of system redundancy with one-sided IO devices and W-LAN connection

4.13 Setup recommendations for optimizing PROFINET

Optimizing PROFINET with RT

PROFINET allows you to set up communication with high-performance with a simultaneously high degree of integration in all levels.

By keeping to the following guidelines, you can further improve performance of your PROFINET IO system in RT mode.

1. Connect a router or a SCALANCE S between the office network and PROFINET system. Through the router, you can determine that the office communication remains exterior.

2. Where useful, set up your PROFINET in a star architecture
   (in the control cabinet perhaps).

Example of an optimized PROFINET topology
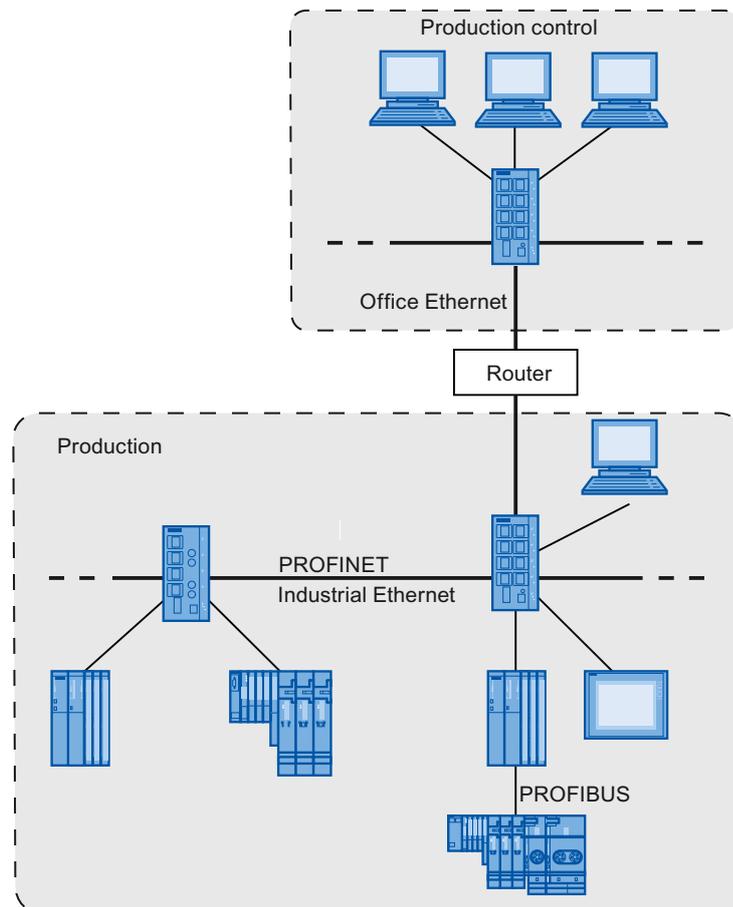

Figure 4-37   Optimized PROFINET topology

Setting up PROFINET with IRT

When setting up and operating a PROFINET IO system in IRT mode, observe the following rules. They serve to ensure an optimum operation of your PROFINET IO system.

1. If only a part of the PROFINET device of a PROFINET IO system is synchronized, then note the following:

   PROFINET devices that do not take part in the IRT communication are placed outside of the sync domain.

2. If you would like to use several sync domains, configure a sync domain boundary for the port that is linked with a PROFINET device of the respective other sync domain.

3. In a sync domain you can configure in each case only one sync master.

4. A PROFINET IO system may only belong to one sync domain.

5. If you configure PROFINET devices in a sync domain and want to synchronize with IRT, the respective PROFINET devices must support IRT communication.

6. If possible, use the same PROFINET device as the PROFINET IO controller and sync master.

Note

Topology configuration

With the usage of IRT, we recommend configuring the topology. STEP 7 can be calculate the update time, bandwidth and other parameters more precisely with this. Communication via PROFINET IO is supported quicker For IRT with the "high performance" option, topology configuration is required.

⚠ CAUTION

Protection by extra low voltage

Modules with PROFINET interfaces must only be operated in LANs in which all the connected network components are supplied with SELV/PELV power supplies or integrated power supplies that afford equivalent protection.

If you connect modules with PROFINET interfaces to a WAN (for example, the Internet), the data transfer point (router, modem, etc) must ensure this protection.

SIEMENS SITOP power supplies, for example, offer this protection.

For additional information, refer to the EN 60950-1 (2001) standard.

Example configuration of PROFINET IO with IRT

The Figure in chapter Configuring real-time communication - introduction (Page 194) shows how a configuration of PROFINET IO systems in a sync domain can look.

Guidelines on PROFIBUS user organization

The installation guidelines can be found on the Internet (http://www.profibus.com/nc/downloads/downloads/profinet-installation-guide/display/).

Commissioning

Information on commissioning an S7 300 IO controller on PROFINET can be found in the S7-300 CPU 31xC and CPU 31x: Installation (http://support.automation.siemens.com/WW/view/en/13008499) Operating Instructions.

Information on commissioning an S7 400 IO controller on PROFINET can be found in the S7-400 automation system, installation (http://support.automation.siemens.com/WW/view/en/1117849) Software Installation Manual.

Information on commissioning an IO device on PROFINET can be found in the ET 200S distributed I/O system (http://support.automation.siemens.com/WW/view/en/1144348) Operating Instructions.

Information on commissioning WinAC RTX on PROFINET can be found in the Windows Automation Center RTX WinAC RTX 2009 (http://support.automation.siemens.com/WW/view/en/38016351) Operating Instructions.

Information on commissioning an S7 modular controller on PROFINET can be found in the Embedded Automation S7-modular Embedded Controller (http://support.automation.siemens.com/WW/view/en/37971572) Operating Instructions.

PROFINET IO System Engineering

<div style="text-align: right; font-size: 3em;">5</div>

Content of this section

This chapter provides you with information on PROFINET IO in greater depth:

- Engineering sequence
- Definition and allocation of device names and IP addresses
- Diagnostics options

5.1 Engineering

Basic steps from planning to operating a plant

Setting up and operating an automation system with STEP 7 or NCM PC involves the following basic steps:

1. Planning the system

   The system planner specifies the following:

   – Scope of functions of the automation system

   – Type and scope of the implemented automation devices

2. Configure the system with STEP 7 or NCM PC

   The configuration engineer creates the project by:

   – Opening an available or setting up a new project

   – Importing new PROFINET devices into the hardware catalog using GSD files, if necessary

   – Inserting more PROFINET devices in the project

   – Networking the automation devices in the network view

   – Assigning device names (not necessary for IO devices where the PROFINET Function "Device replacement without removable media / PD" has been configured).

   – Creating the user program

   – Checking the configuration

   – Updating and documenting the project

3. Commissioning and testing the plant

   The commissioning engineer performs the following tasks:

   – Commissioning the automation devices

   – Downloading the project data to the automation devices of the system

     The device name is then assigned to a real device with a MAC address.

   – Revising the configuration and / or the user program in STEP 7, if necessary

   – Testing the system

4. Operating the plant.

   The plant operator performs the following tasks:

   – Monitoring and changing the process data online

   – Running diagnostics on the system

   – Operator control and monitoring

5. Performing maintenance and modifications.

Integration using a GSD file

New PROFINET devices are integrated using a GSD file. The properties of a PROFINET device are described in a GSD file (General Station Description) that contains all the information required for configuration.

In PROFINET IO, the GSD file is in XML format. The structure of the GSD file conforms to ISO 15745, the worldwide standard for device descriptions.

GSD import, engineering and exchange of data
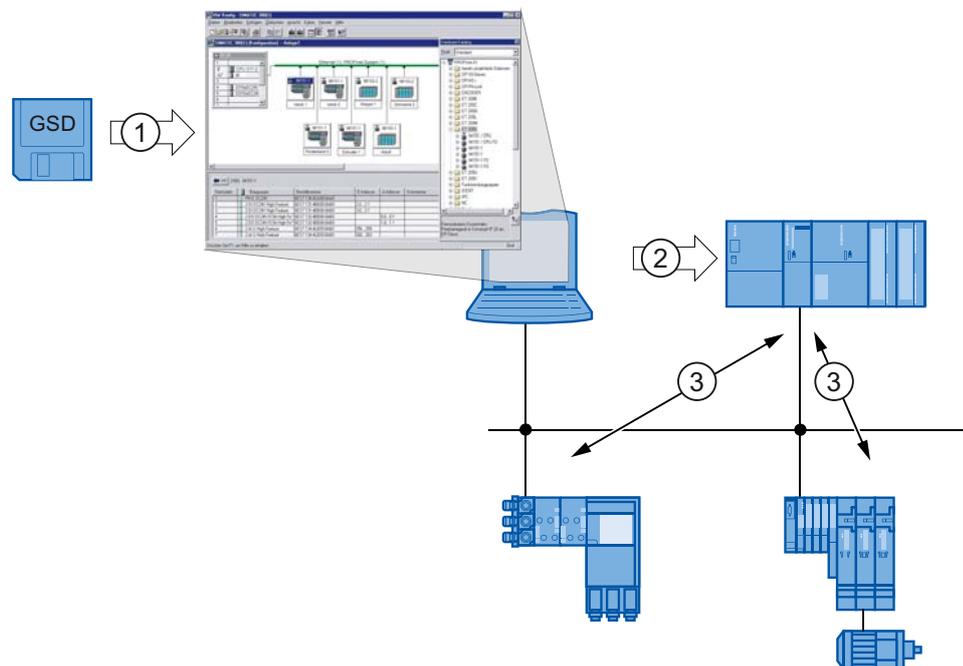
Number	Description
①	The device description is imported into the engineering system as a GSD file.
②	The configuration is carried out in the engineering system (for example STEP 7). The configuration and the user program are then transferred to the IO controller.
③	Once you have assigned device names to the IO devices, the data is exchanged between the IO controller and assigned IO devices automatically.

Figure 5-1   From GSD import to exchange of data

Downloading User Program from programming device/PC to PLC

The PG/PC interface parameter settings include the TCP/IP protocol for downloading the user program to the PLC over Industrial Ethernet via a programming device/PC.

You can also download the user program to the PLC via MPI and PROFIBUS.

Support from STEP 7

STEP 7 supports you from the planning stage through to operation of a plant as follows:

- Management of PROFINET device data in the hardware catalog.

- Networking of devices in the network view (NETPRO) and / or in HW Config (configuration view in STEP 7).

  In the network view, you can link devices to a PROFIBUS or Industrial Ethernet subnet graphically and assign the relevant addresses.

- Configuration of the PROFINET CPs in STEP 7. Remember that, under certain circumstances, you must configure, program, and run diagnostics with CPs differently from the integrated interface of a CPU. For additional information, refer to the relevant manual.

- Monitoring and modifying variables online

- You can access the process data online at any time. To do so you can use a variable table or integrate HMI devices such as ProTool/Pro RT or WinCC flexible into your system, or use OPC-based client programs.

- Running diagnostics on PROFINET devices

  The current status of the PROFINET devices is displayed in a separate diagnostics window. With an online-offline comparison, you can determine whether or not it is necessary to download programs and/or a configuration to the automation systems.

- Presentation of the project in a hierarchical tree structure

  All parts of the system are represented in a clearly identifiable way that allows convenient navigation and other management functions in the project.

- Support in creating system documentation

  STEP 7 automatically creates comprehensive documentation for the configured system including all devices and their connections.

- Checking the configuration

  STEP 7 automatically checks the following circumstances:

  – Has the specified configuration limits been observed in the project?

  – Is the configuration consistent and free of errors?

- Looking up online device data

  With the online device analysis, you can look up online data of individual devices for test and diagnostic purposes.

- Running diagnostics on the switches

  You can use STEP 7 to run diagnostics on the integrated switch functions.

  Diagnostics can be run on SCALANCE X200, SCALANCE X300 and SCALANCE X400 series switches as PROFINET IO devices.

Commissioning a PROFINET interface of a CPU

Details on SIMATIC CPU can be found in the S7-300 CPU 31xC and CPU 31x: Installation (http://support.automation.siemens.com/WW/view/en/13008499)Operating Instructions and in the S7 400 automation system - Design and application (http://support.automation.siemens.com/WW/view/en/22586851) System Description.

Information on commissioning WinAC RTX on PROFINET can be found in the Windows Automation Center RTX WinAC RTX 2009 (http://support.automation.siemens.com/WW/view/en/38016351) Operating Instructions.

Information on commissioning an S7 modular controller on PROFINET can be found in the Embedded Automation S7-modular Embedded Controller (http://support.automation.siemens.com/WW/view/en/37971572) Operating Instructions.

CPU communication

In PROFINET IO, you configure and program communication between the IO controllers as an S7 connection or Send/Receive connection as usual.

Open communication via Industrial Ethernet

STEP 7 gives you the following FBs and UDTs for exchanging data with other Ethernet-capable communication partners.

1. Connection-oriented protocols: TCP native as per RFC 793, ISO on TCP as per RFC 1006:

   – UDT 65 "TCON_PAR" with the data structure for assigning connection parameters

   – FB 65 "TCON" for establishing a connection

   – FB 66 "TDISCON" for terminating a connection

   – FB 63 "TSEND" for sending data

   – FB 64 "TRCV" for receiving data

2. Connectionless protocol: UDP as per RFC 768

   – UDT 65 "TCON_PAR" with the data structure for assigning parameters for the local communications access point

   – UDT 66 "TCON_ADR" with the data structure for assigning addressing parameters for the remote partner

   – FB 65 "TCON" for configuring the local communications access point

   – FB 66 "TDISCON" for closing the local communications access point

   – FB 67 "TUSEND" for sending data

   – FB 68 "TURCV" for receiving data

Additional information

For additional information on CPU communication, refer to the Communication with SIMATIC (http://support.automation.siemens.com/WW/view/en/1254686) Manual and the System Software for S7-300/400 System and Standard Functions (http://support.automation.siemens.com/WW/view/en/1214574) Reference Manual.

5.2 Configuration

Configuration of the PROFINET interface in STEP 7

The parameters of the PROFINET interface can be changed with the aid of the "Properties" dialog box for the respective module in HW Config of STEP 7.

Configuring an example of a CPU 416-3 PN/DP

1. Select the module, the PROFINET interface of which should be configured. This is shown exemplarily by the CPU 416-3 PN/DP control.

2. Call the "Properties" dialog box of the PROFINET interface or its port(s) by double-clicking:

   – PN-IO (PROFINET interface X5)

   – Port 1 (port 1 of interface X5: X5 P1 R)

   – Port 2 (port 2 of interface X5: X5 P2 R)
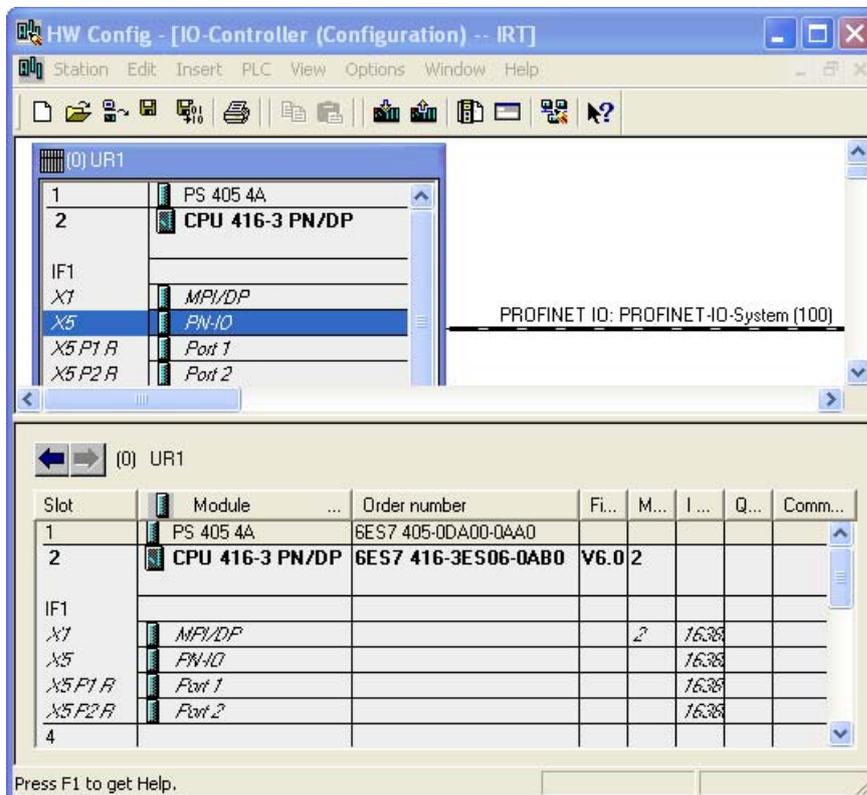
3. The following PN interface parameters can be edited or displayed via the describing tab:

General

– Name of the interface of the IO controller

– IP address

– Subnet mask

– Gateway

– Device replacement without removable medium

– Obtain device names with a different method

Addresses

– Diagnostics address of the interface of the IO controller and of the IO system itself

PROFINET

– Send clock (can only be edited in the "Synchronization" tab, if the PROFINET device is not configured in the "PROFINET" tab)

– IO communication traffic of PROFINET IO and PROFINET CBA

– Call OB 82 for communication alarm

I-device

– I-device mode

– Transfer area information

Synchronization

– Synchronization role

– Name of the sync domain (can be edited in the PROFINET IO domain management)

– RT class

– IRT option

Media redundancy

– MRP- Domain

– Role within the domain

– Ring ports

Time synchronization

– NTP process with update interval

Options

– KeepAlive interval for connections
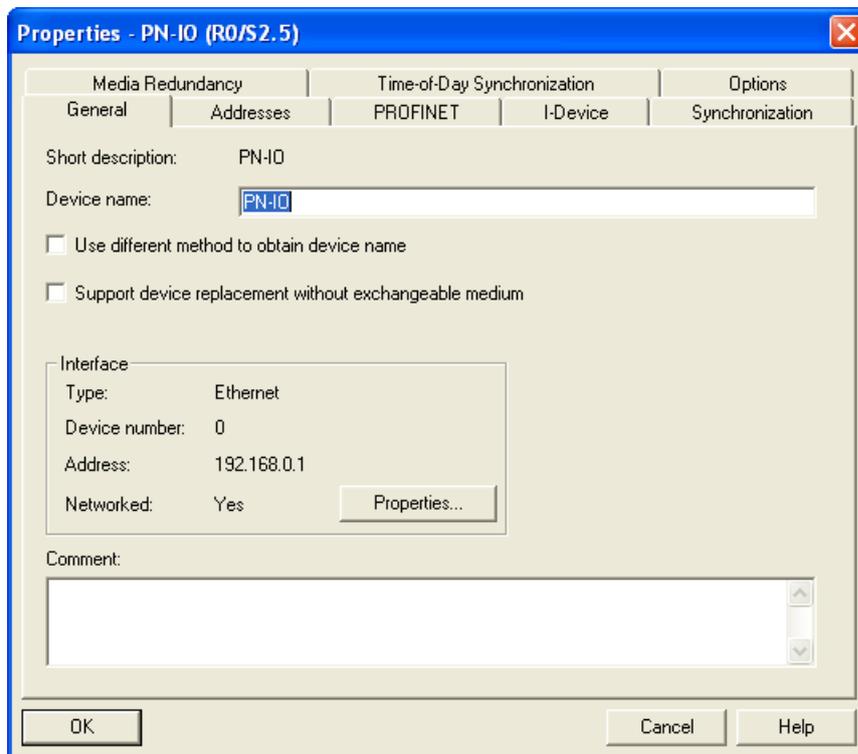
4. The following parameters of a PN port can be edited or displayed:

General

– Name of the port of the IO controller

Addresses

– Diagnostics address of the port

Topology (also editable in the topology editor)

– Partner port

– Cable data

Options

– Transmission medium with transmission rate

– Disabling auto-negotiation

– Different boundaries: End of the sync domain, end of recording available nodes, end of the topology detection

5.3   Topology and STEP 7

5.3.1   The SIMATIC topology editor

Introduction

With STEP 7, you can configure your PROFINET IO-system topologically. With the topological configuration you can use the PROFINET function like "Changing IO devices (partner ports) during operation" or "Device replacement without removable data / PD". For IRT with the "high performance" option, topology configuration is required.

The topology editor supports you in the following tasks:

- Obtaining topology information about all ports of the PROFINET devices in the project

- Configuring the set topology on PROFINET by interconnecting the interfaces and ports by simply dragging and dropping and establishing properties

Functions

The topology editor has a series of functions for setting, interconnecting and diagnosing the properties of all PROFINET devices including their ports.

The following functions and information are available:

- Display of all PROFINET devices and their ports in the project

- Configured cable lengths and configured type of cable with calculated signal running time for each port

- Interconnection data with local identification of the individual PROFINET devices

- Diagnostics information of PROFINET devices for each individual port

- Simple fault detection with online / offline comparison of the node data

- Call of the diagnostics (module information) from the graphic view

- Importing the network topology

Tabular view
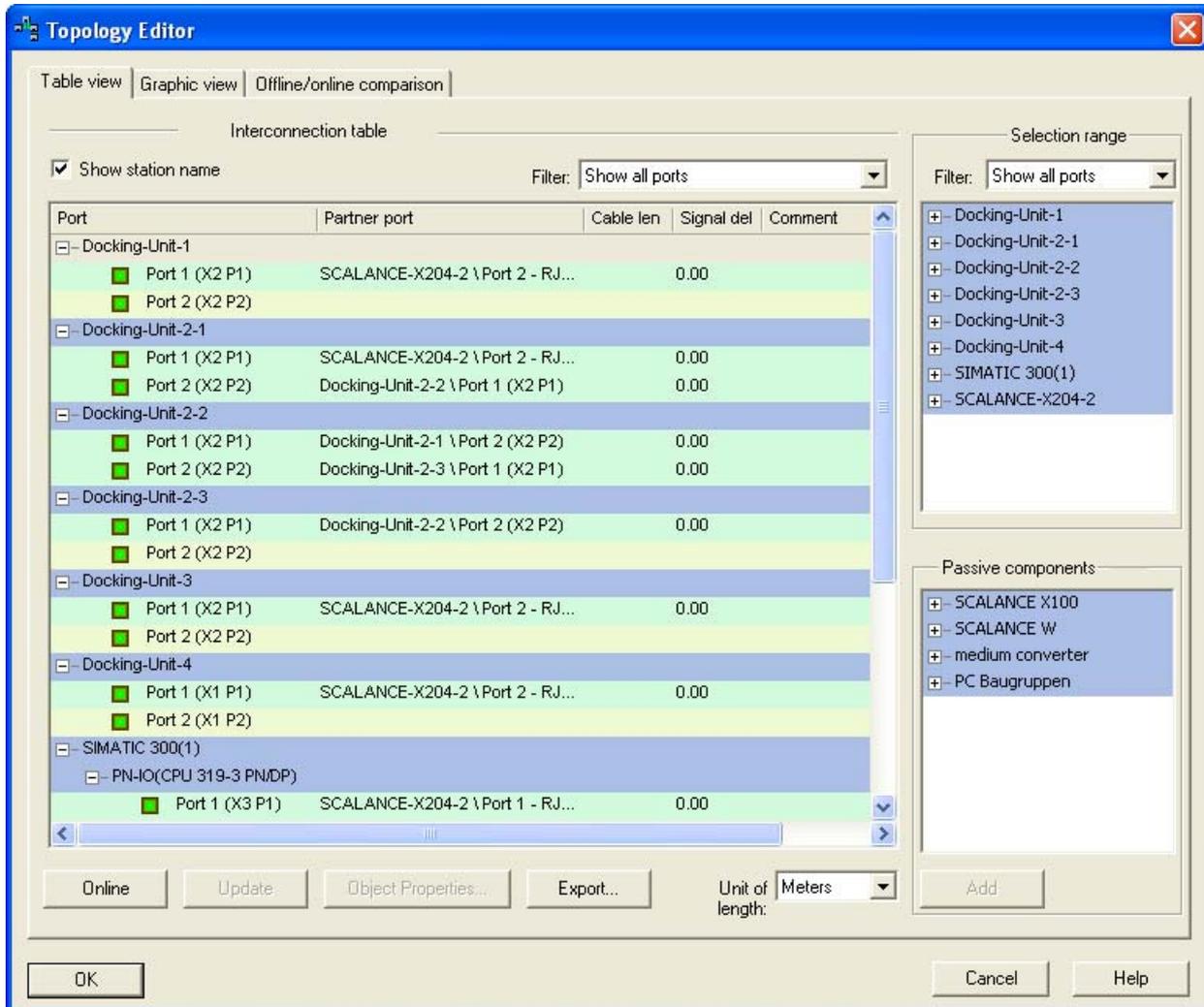
Figure 5-2   "Tabular view" tab of the topology editor

The "interconnection table" in the left area of the tab "Tabular view" lists all the configured PROFINET devices with their ports. The selection area in the top, right section lists all the PROFINET devices that are available for the topological interconnection.

Via the "Filter" drop-down list you can select from the following display options:

- "Show all ports": both interconnected as well as non-interconnected ports are listed

- "Show interconnected ports": only interconnected ports are listed

- "Show non-interconnected ports": only non-interconnected ports are listed

Graphic view
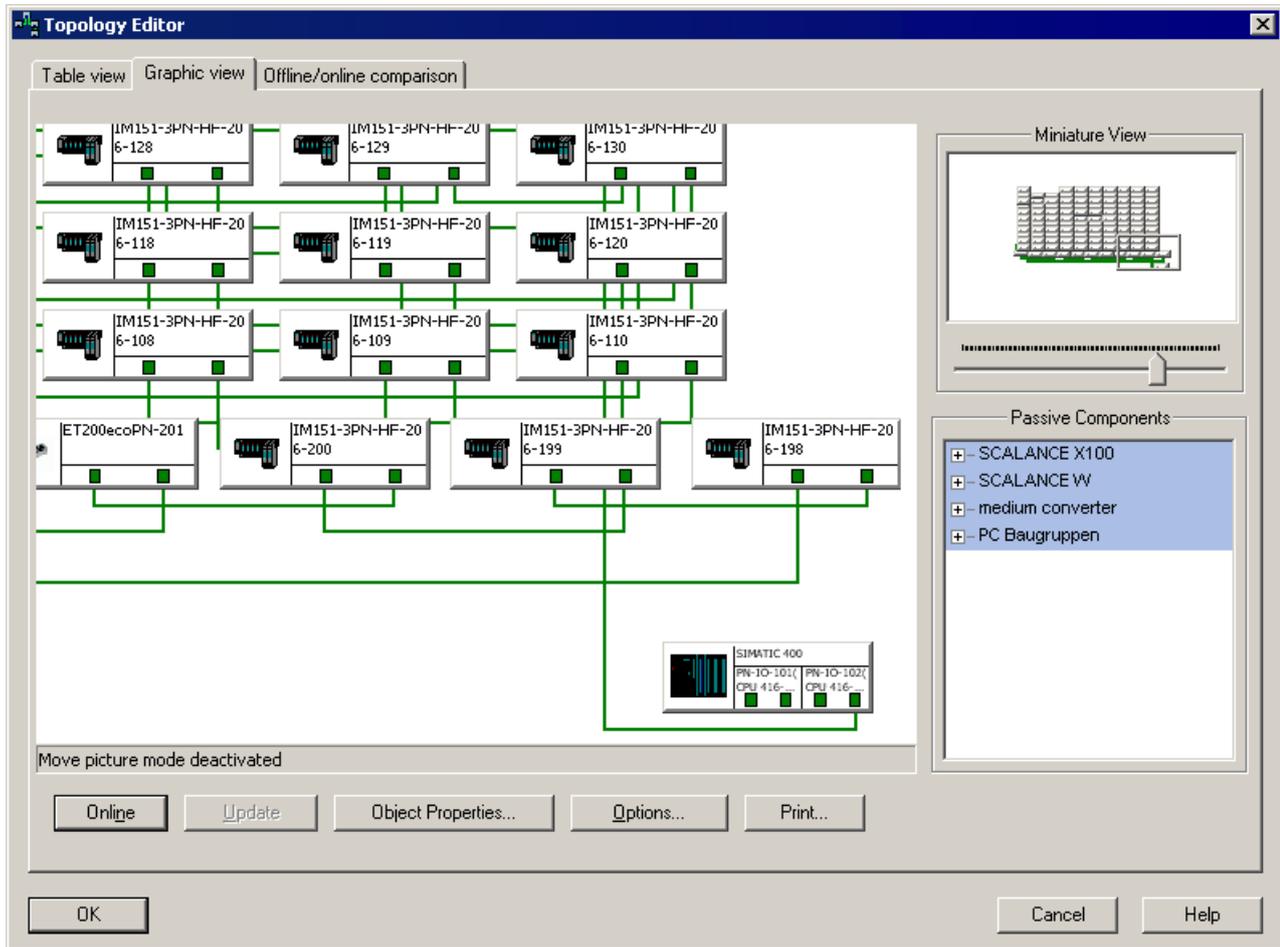
Figure 5-3   "Graphic view" tab of the topology editor

The "Graphic view" tab displays the PROFINET devices in the project and their interconnections.

In the miniature view in the top, right section, you can use the slider to select the section of the PROFINET IO system and its enlargement factor. To change the section of the PROFINET IO system, use the mouse to drag the frame across the desired area that you wish to see in detail.

Online/offline comparison
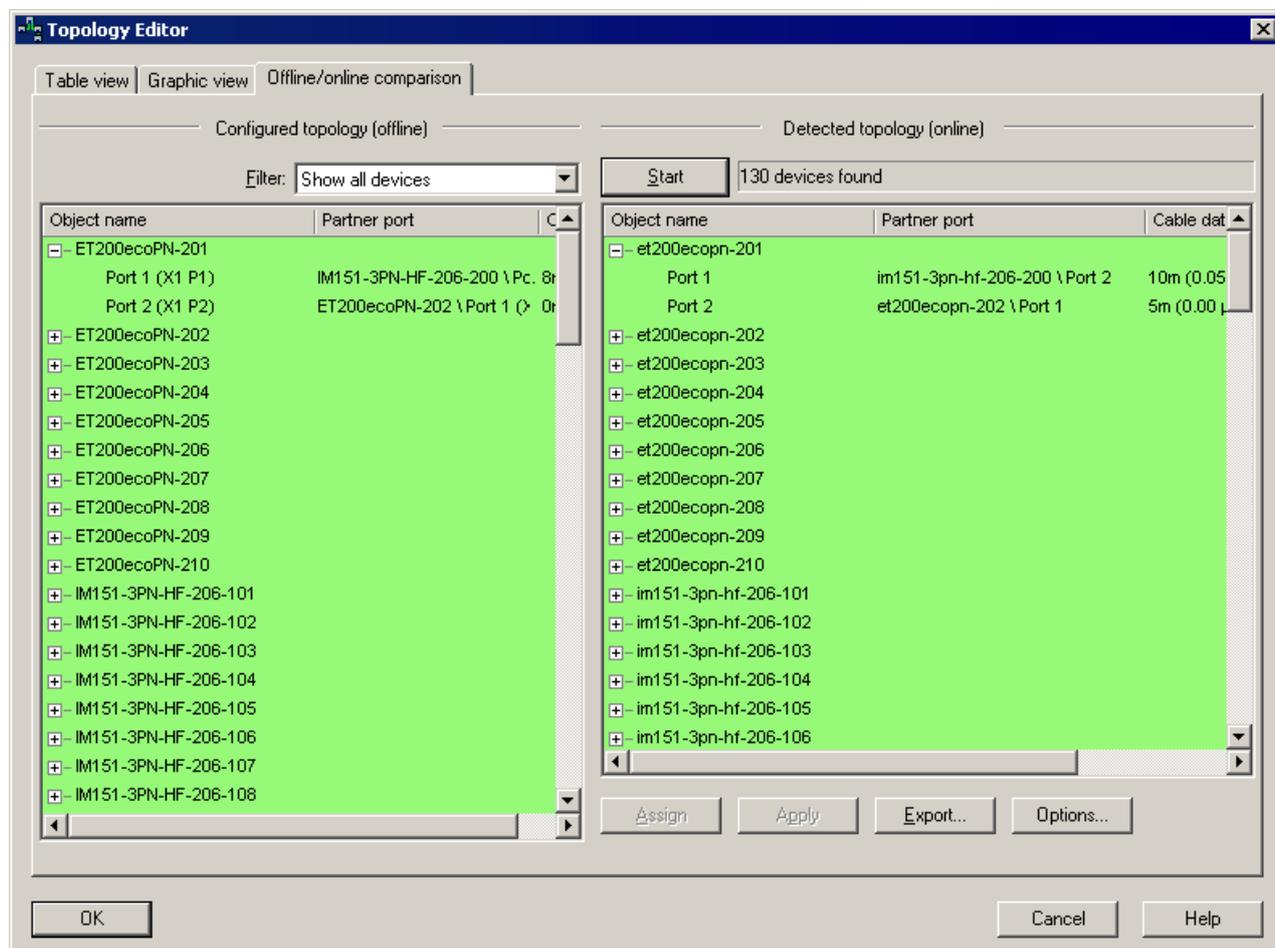
Figure 5-4   "Online/offline comparison" tab

The "Offline/online comparison" tab in the left area "Configured topology (offline)" lists the configured PROFINET devices with their interfaces and ports and the associated neighbor ports. The right section "Detected topology (online)" shows the online view of the PROFINET IO system with its interconnection for the runtime.

Note

Cable data

The display of the cable length is an estimated value on the basis of the determined signal running time. Particular for short lines, the displayed value may be considerably different from the actual length due to the very short signal running time sand the rounding errors connected this.

Additional information

For additional information about setting up and handling the topology editor, refer to the STEP 7 Online Help.

5.3.2   Configuring a topology

Topology editor - start

Start the topology editor as follows:

- Select the respective PROFINET IO system.

- In HW Config or NetPro with the menu command **Edit > PROFINET IO > Topology**

- Via the shortcut menu of an interface, a port of the respective PROFINET device or via the shortcut menu of the PROFINET IO system with the menu command **PROFINET IO Topology**

Interconnection and properties

To interconnect ports of the PROFINET devices, proceed as follows:

1. In the "Table view" tab, in the "Selection area" select the port of the PROFINET device that you wish to interconnect.

2. Drag this port to the desired port of a PROFINET device in the "interconnection table".

   The "Interconnection properties" dialog box for the selected port now opens.
   The Figure below shows an example of such a configuration.
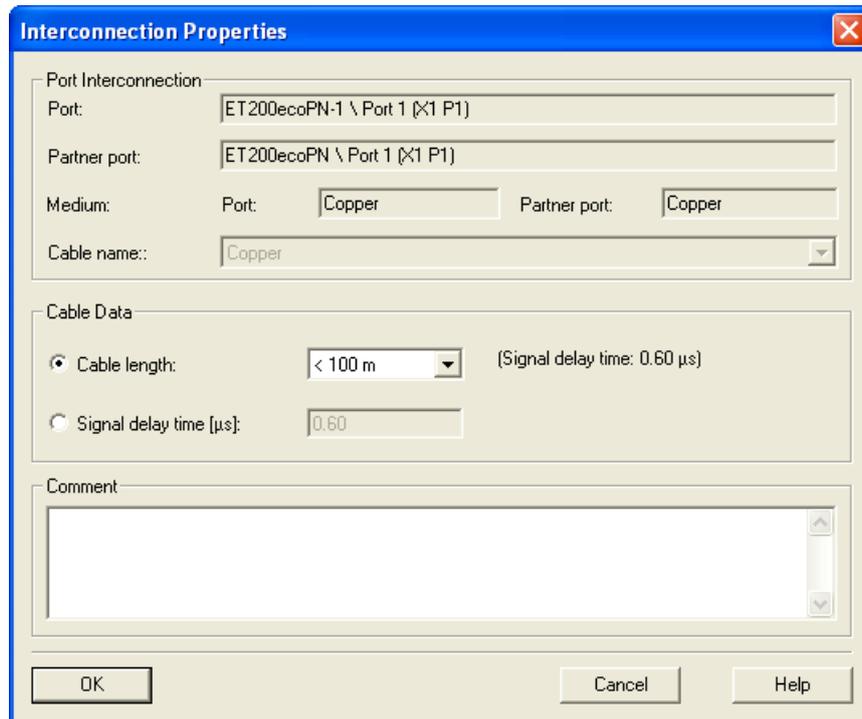
Figure 5-5   Interconnection and configuration of the port

The name both of the selected port as well as of its partner port with its PROFINET devices is displayed in the "Port interconnection".

3. IF you wish to change the default values for the cable data, either click on the "cable length" option field and select the desired value from the drop-down list, or click on the "signal delay time" option field and enter the desired value.

4. Save the settings and end the dialog with "OK".

Object properties of a port

Alternatively, you can select a partner port via the "Properties" dialog box of a port. By selecting the partner port, the neighborhood between the two ports is determined and the properties of the cable can be edited.

1. Open the dialog by selecting the port of the module and double-clicking the "Object properties" button or on the port itself.

2. Then select the "Topology" tab.
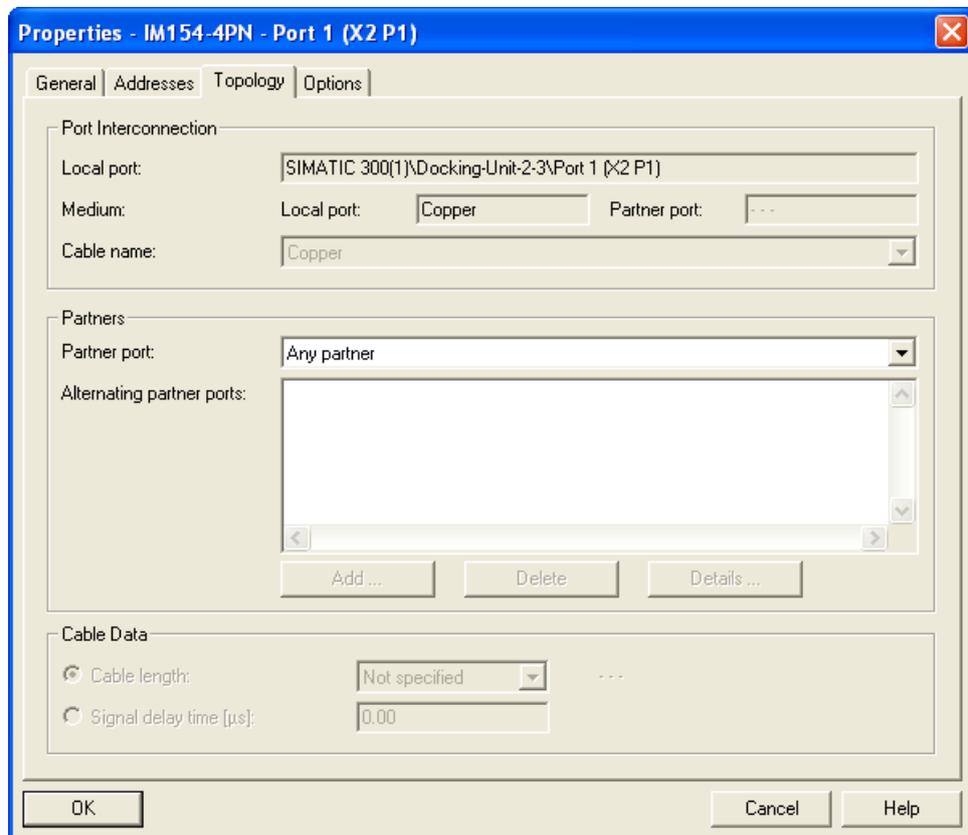
Figure 5-6   Interconnection and configuration of the PROFINET interface

3. In the "Partner port" drop-down list, select the port with which you want to interconnect the device or select the entry "Alternating partner port".

4. IF you wish to change the default values for the cable data, either click on the "cable length" option field and select the desired value from the drop-down list, or click on the "signal delay time" option field and enter the desired value.

5. Save the settings and end the dialog with "OK".

Accept the topology of connected PROFINET devices in the topology editor

If the PROFINET IO system has already been set up and the PROFINET devices connected, these do not need to be first of all interconnected to a topology within the project, you can simply import them into the project in just a few steps:

1. Start the topology editor

2. Click on the "Offline/online comparison" tab.

3. Click "Start" to import the PROFINET devices of your project.

   The following Figure shows an example project in which PROFINET devices have been imported.
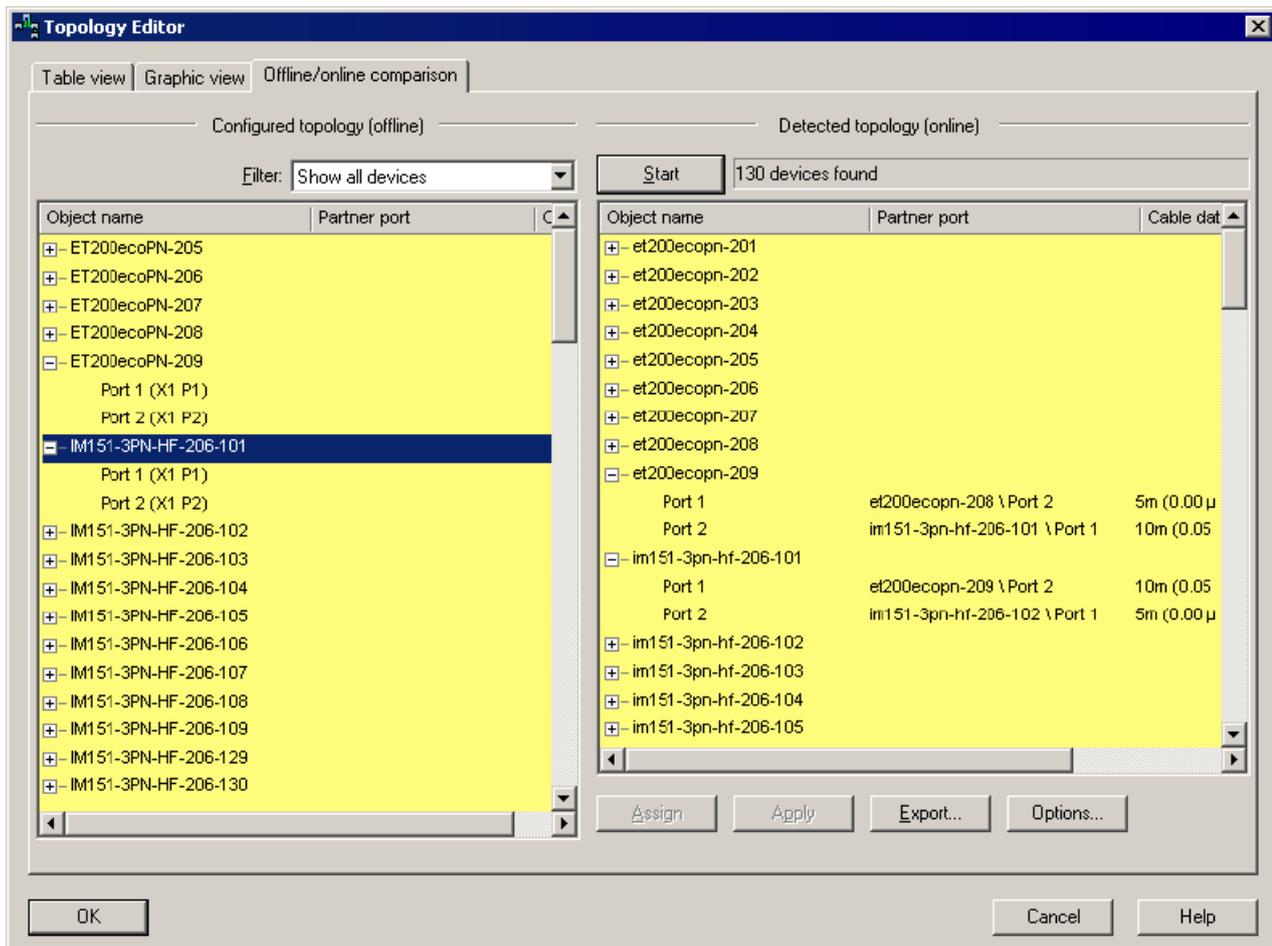
Figure 5-7   Comparison of the configured and imported topology

4. To import the topology of the PROFINET devices, select all ports of the detected topology in the area "Detected topology (online)."

5. Click on the "Apply" button. The topology of the configured IO system is loaded to the project.

6. Save the settings and end the dialog with "OK".

Result

The topological information of the respective PROFINET IO system is specified in the topology editor and can be used for further amendments or additions to the project. Once the topology has been loaded successfully, the color in both areas changes from yellow to green.

5.4 Configuring the real-time communication

5.4.1 Introduction

PROFINET IO system with configuration of the RT and IRT communication
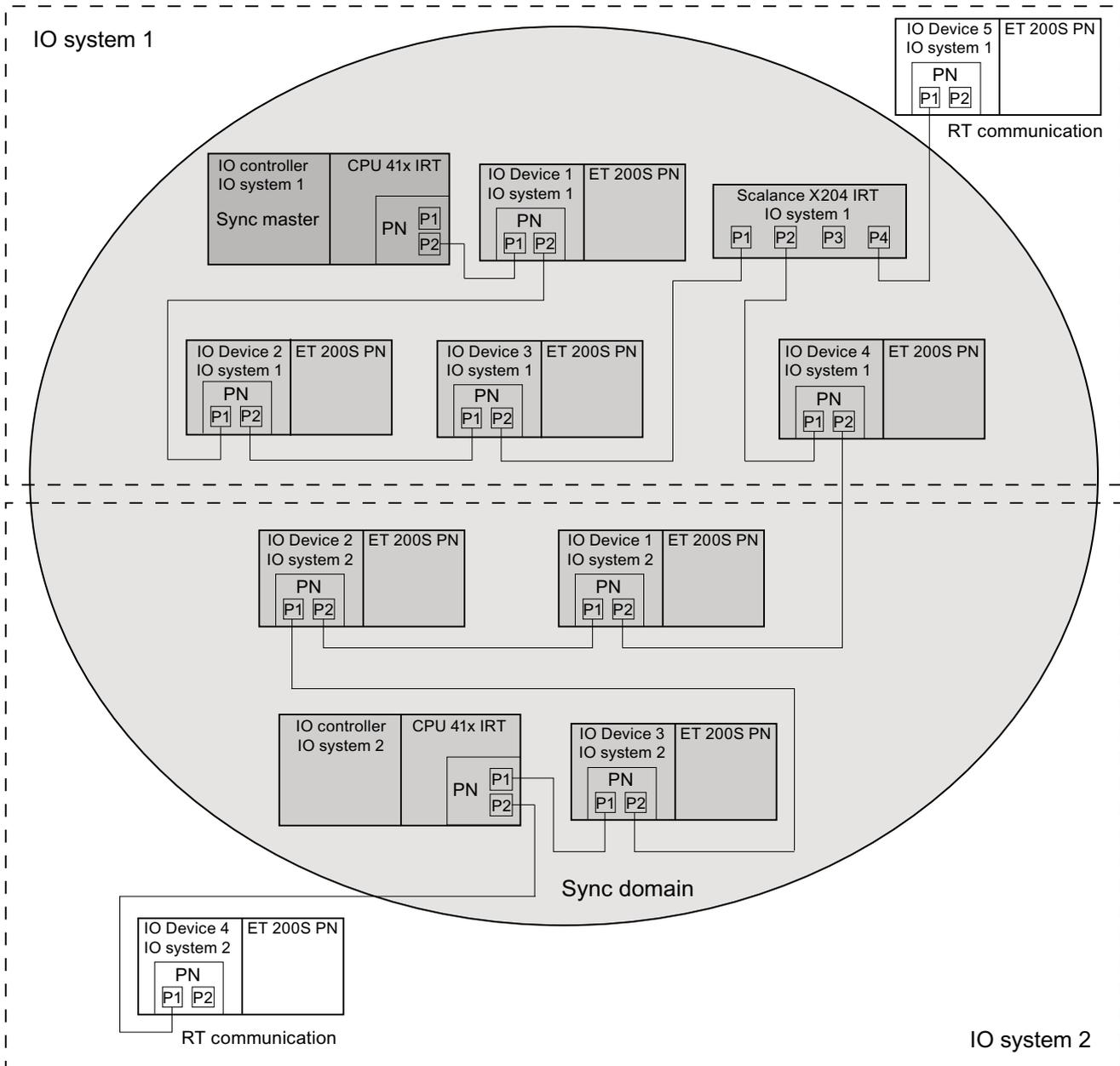
Figure 5-8   Example configuration of two PROFINET IO systems with IRT and RT communication
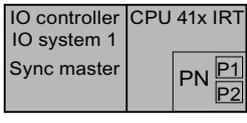
IO controller IO system 1 / Sync master — CPU 41x IRT — PN P1 P2	IO controller - sync master
IO controller IO system 2 — CPU 41x IRT — PN P1 P2	IO controller - sync slave
IO Device 1 IO system 1 — ET 200S PN — PN P1 P2	IO device - sync slave
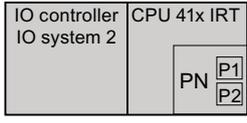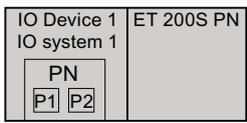
Recommendation for configuring the RT real-time communication

- The more nodes a message frame must allow through from the IO controller to the IO device (line depth), the greater the response check time of the respective IO device should be.

- If the response check time remains on the setting selected by STEP 7, then the linear depth can be up to about 50 IO devices with an update time of 2 ms. A higher update time or an adjustment to the response check time allows for greater linear depth.

Note

Update time in STEP 7

The update time of the RT IO devices is set by STEP 7 / HW Config in the default setting of the mode for the update time ("automatic") to a minimum of 2 ms and the response check time to 6 ms.

You can decrease the update time for each IO device if you want to update your PROFINET IO system in smaller intervals, whereby, for example, you can set a "fixed update time" for specific IO devices.

Recommendation for configuring the IRT real-time communication

- STEP 7 makes available the best possible update time for IRT.

- STEP 7 sets the send clock to 1 ms as a default. This way, update times greater than or equal to 1 ms will be achieved.

- Only if you require shorter update times than 1 ms for your application should you set the send clock to the minimum required update time.

Recommendation for configuring IRT with the "high flexibility" option

- If you want to optimize the use of the transmission bandwidth without specifying a set topology, you can adapt the parameter "Max. IRT stations in line" to the actual available network topology of your system, as follows:

  – Select the "PROFINET" tab in the "Properties" dialog box of the PN interface of the IO controller.

  – Clear the "System settings" check box.

  – In the input field "Max. IRT stations in line", enter the number of IO devices being used.

Note

Optimum settings with set topology

- If you have configured "Set topology", the parameter already has its optimum value.

- IRT with the "high performance" option always requires topology configuration. Through the topology configuration, IRT with "high performance" reaches a considerably better usage of the available bandwidths. Through this, higher linear depths and shorter update times than with the "high flexibility" option of the IRT are possible.

In general:

- If cable connections between two communication nodes from several PROFINET IO systems are being used together, you can add up the communication loads of the individual PROFINET IO systems via the available transmission bandwidth. You should therefore keep the cable connections for several PROFINET IO systems separate from each other in order to achieve optimum update times.

- If, nevertheless, you want to use mutual cable connections for several PROFINET IO systems, you must increase the update times for those IO devices which are positioned behind mutually used communication connections. This way you prevent communication overload.

Note

Topology and update time

To achieve the best possible update times, it is best if you select a star or tree topology.

Note

Failure of the sync master with IRT with "high flexibility" (example from image 5-8)

If the sync master, which is also simultaneously the IO controller of the PROFINET IO system 1, fails in this sync domain, this will have the following consequences for IRT with "high flexibility":

- The IO devices in the PROFINET IO system 1 also fail because when the sync master fails, your IO controller also fails. (The output I/O of the IO device then issues substitute values).
- The PROFINET IO system 2 continues to work with its IO controller.
- The communication of the PROFINET devices of system 2 is no longer synchronized.
- All PROFINET interfaces of the PROFINET devices in the sync domain report the synchronization loss as a maintenance request.
- The exchange of the user data in the PROFINET IO system 2 is still possible, but takes place without synchronization between the PROFINET devices (corresponds then to a user data exchange as with RT).

Note

Failure of the sync master with IRT with "high performance" (example from image 5-8)

If the sync master, which is also simultaneously the IO controller of the PROFINET IO system 1, fails in this sync domain, this will have the following consequences for IRT with "high performance":

- The IO devices in the PROFINET IO system 1 also fail because when the sync master fails, your IO controller also fails. (The output I/O of the IO device then issues substitute values).
- The PROFINET IO system 2 continues to work with its IO controller.
- The synchronized PROFINET IO devices of the system 2 fail.
- The exchange of usage data in the PROFINET IO system 2 is only possible with the unsynchronized PROFINET-IO devices. At the point in time of the failure of the sync master, however, there may be short-term communication failures of the unsynchronized PROFINET IO devices.

5.4.2 Configuring the IRT communication of individual devices

Configuring individual PROFINET devices in a sync domain - overview

If you want to configure the IRT communication of individual PROFINET devices, proceed as follows:

1. You insert the IO controller in your project and configure it. PROFINET devices for which you configure IRT communication must support IRT with your selected option ("high flexibility" / "high performance").

2. You configure the IRT communication for the IO controller by setting the RT class to IRT.

3. You add a PROFINET device to the Ethernet of the IO controller and configure it as usual.

4. You configure the IRT communication for the added PROFINET device by setting the RT class to IRT and selecting the desired IRT option.

5. Establish the send clock and the reserved communication traffic for the IRT data for the respective sync domain.

6. If you have selected the IRT with the "high performance" option, the topology configuration is necessary.

7. Download the configuration to the device.

Note

Rules for setting up a PROFINET IO system

- Only devices with the same IRT option may be configured within a sync domain.
- Please note the setup recommendations in chapter Setup recommendations for optimizing PROFINET (Page 173).
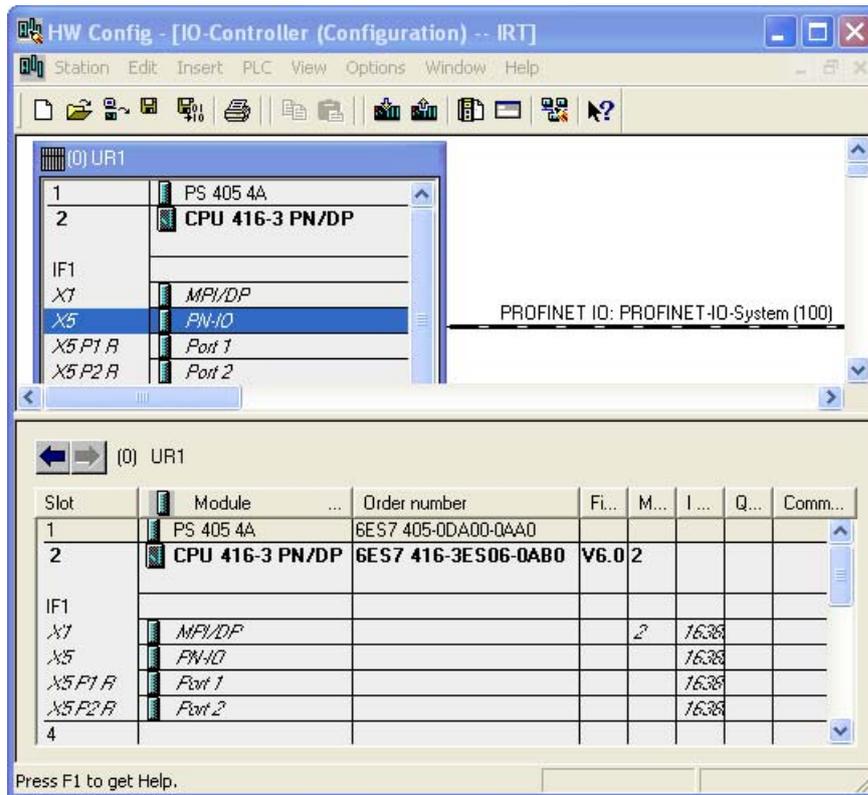
Figure 5-9   Initial example with configured IO controller

Configuring the IO controller in the default sync domain

As the first PROFINET device, you configure the IO controller in the (default) sync domain.

Procedure in HW Config

1. Open the "Properties" dialog box of the PN interface by double-clicking the PN interface symbol (X3 PNIO).

2. Configure the IO controller as a sync master. To do this, change the synchronization table of the IO controller to "sync master". STEP 7 automatically adjusts the RT class and IRT option of the IO controller to the setting selected in the devices.
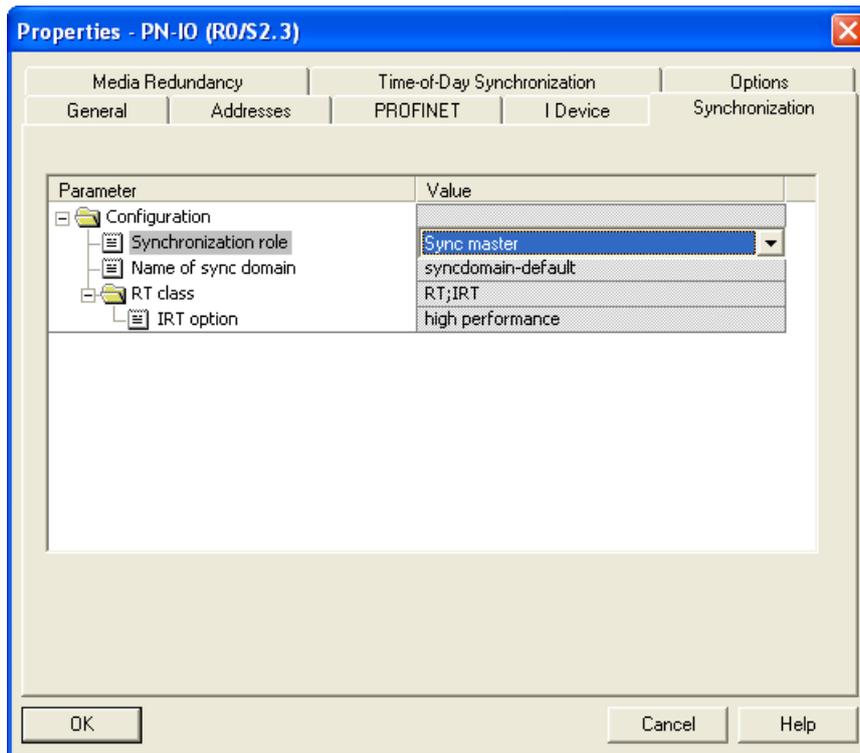
Figure 5-10   Configuring the PROFINET interface

3. Save the settings and end the "Properties" dialog box with "OK".

4. Insert an IO device from the hardware catalog in the PROFINET IO system.

5. Open the "Properties" dialog box of the respective IO device by double-clicking the PN IO-interface.

6. The "Properties" dialog box of the respective IO device then opens.

7. Configure the IO device as a sync slave. To do this, change the synchronization table of the IO device to "sync slave". STEP 7 automatically changes the RT-class from "RT" to "IRT". Depending on the planned configuration, change the IRT option to "high performance" or to "high flexibility".

8. Save the settings and end the "Properties" dialog box with "OK".

9. Repeat steps 5 and 9 for all other IO devices you want to synchronize.

Result: You have configured the sync domain with PROFINET IO system

Using the "Domain management" dialog you can check the settings of the PROFINET IO system. You open the dialog by selecting "PROFINET IO domain management ..." from the shortcut menu of the PROFINET IO system.
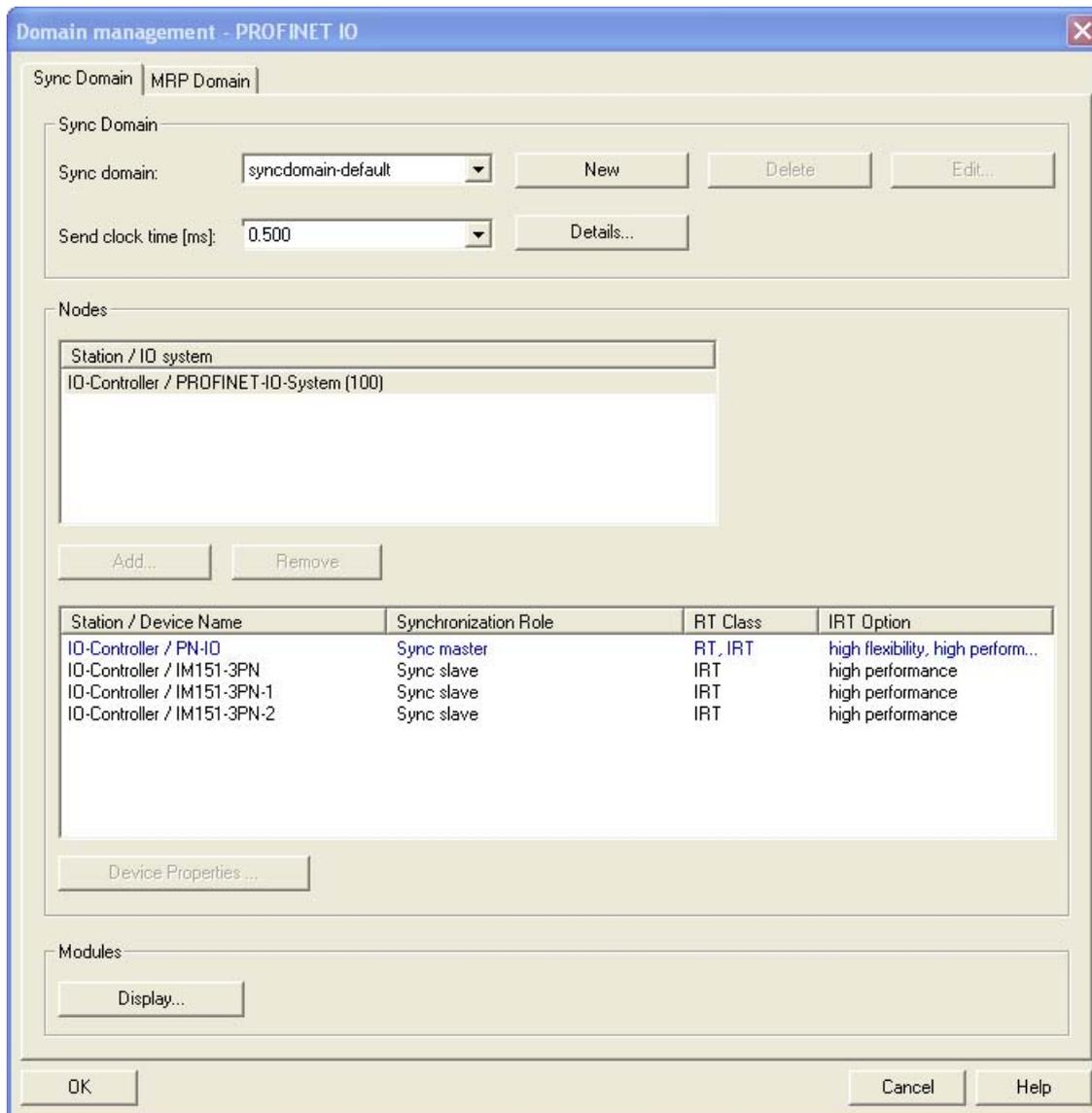
Figure 5-11   PROFINET IO system in sync domain "syncdomain default"

The PROFINET IO system in the example consists of a CPU 319-3 PN/DP and a distributed I/O device ET 200S.

See also

Setup recommendations for optimizing PROFINET (Page 173)

Isochronous real-time (Page 67)

5.4.3 Configuring the IRT communication of a PROFINET IO system

Configuring a sync domain via the "Sync Domain management" dialog - overview

If you want to configure the IRT communication for the user data exchange of a PROFINET IO system, proceed as follows:

1. As before, you configure stations with PROFINET IO controllers and PROFINET IO devices. PROFINET devices for which you configure IRT communication must support IRT with the desired IRT option.

2. You configure a sync domain and set up for each individual PROFINET device its synchronization role in the sync domain. An IO controller or a switch is configured as a sync master, all other PROFINET devices of the sync domain you assign the role of a slave.

3. If you have selected the "high performance" option, now you can configure the topology.

4. Establish the send clock and the reserved communication traffic for the IRT data for the respective sync domain.

5. Download the configuration to the PROFINET device.

Note

Rules for setting up a PROFINET IO system

- We recommend also operating the IO controller as a Sync-Master if you configure the IRT communication with the option "high performance". Otherwise, IRT and RT configured devices may fail if the sync master fails.

- Please note the setup recommendations in chapter Setup recommendations for optimizing PROFINET (Page 173).

Conditions for configuring the default sync domain

You have configured a PROFINET IO system with IRT-capable PROFINET devices (example in the following graphic) and opened the configuration in HW Config.
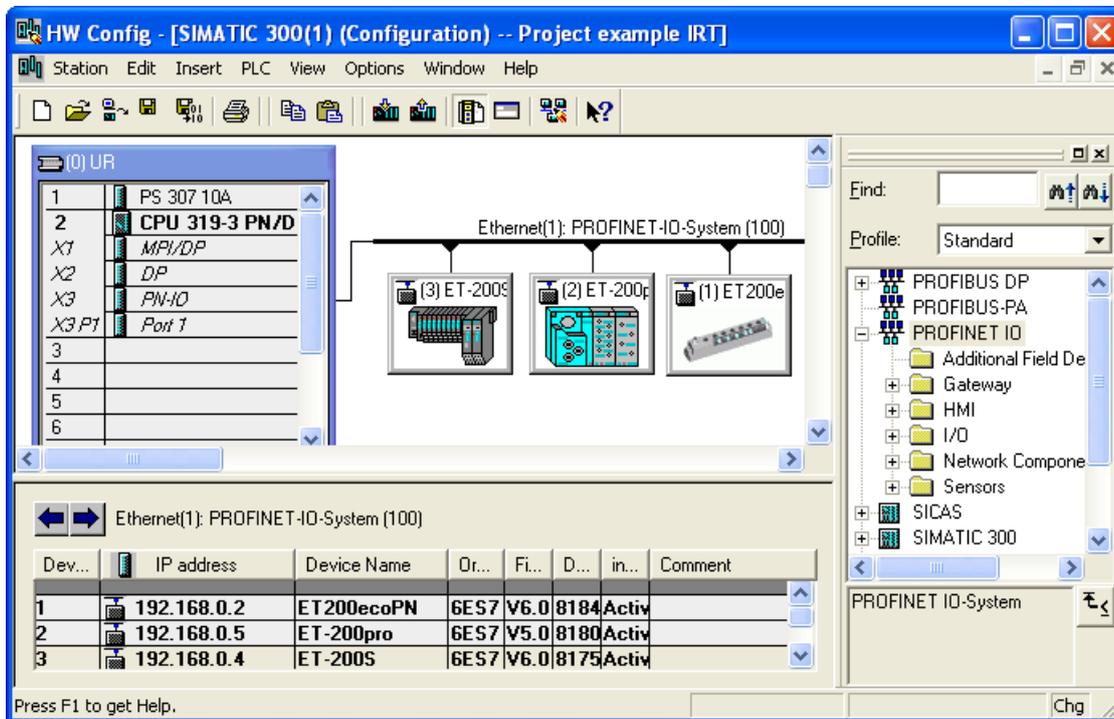
Figure 5-12   Example - configuring a PROFINET IO system

Configuring a PROFINET IO system in the default sync domain

STEP 7 uses the default sync domain with the name "syncdomain-default" (name cannot be chosen). This is permanently available and cannot be deleted.

Procedure in HW Config

1. Open the "Domain management" dialog box. In the HW Config, under the shortcut menu of the PROFINET IO system (railway tracks) select the menu command **PROFINET IO Domain Management.**
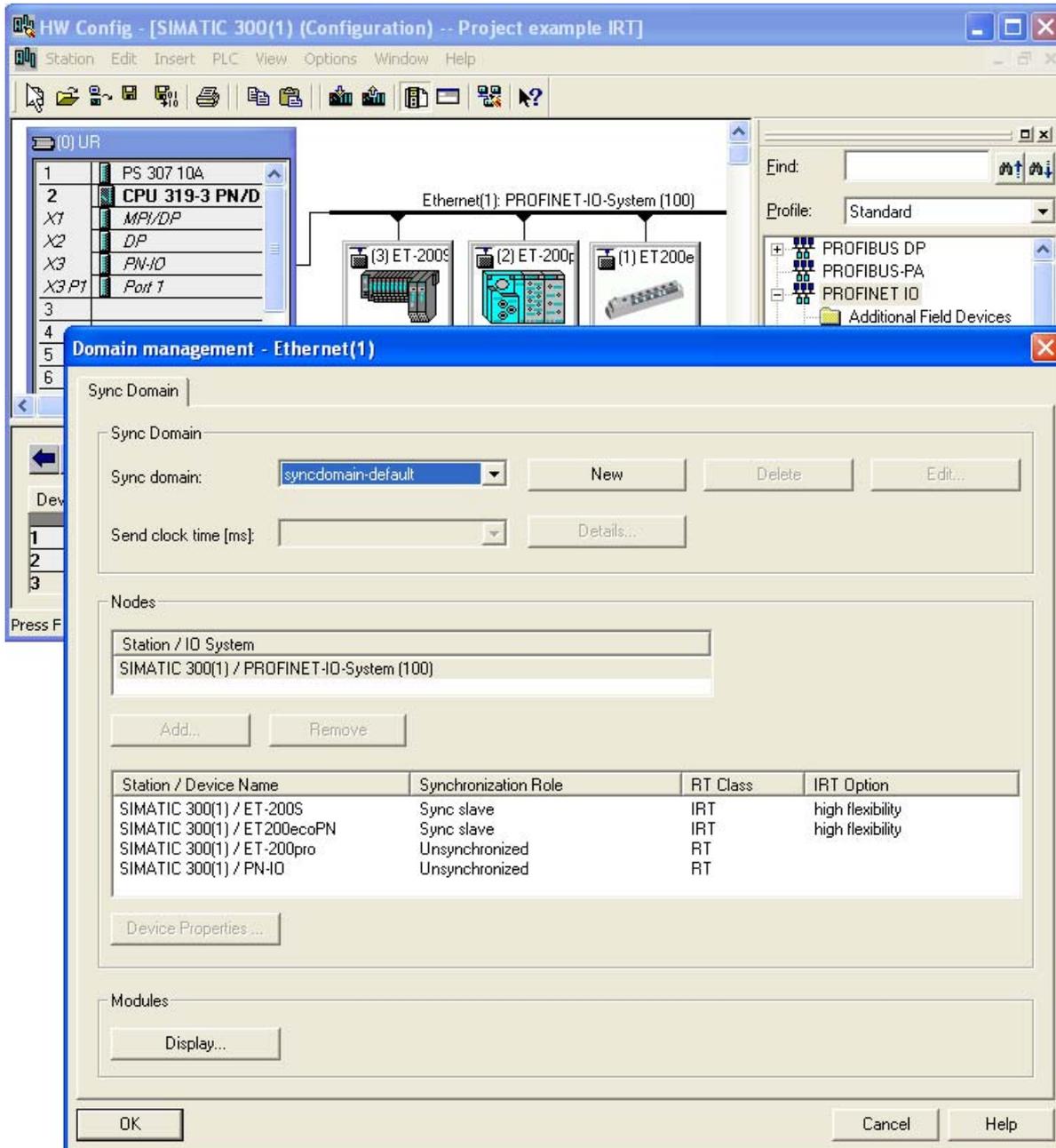
Figure 5-13   Sync domain management

The name of the sync domain is automatically assigned by STEP 7 with "syncdomain-default" when the first sync domain is configured. Alternatively you can create further sync domains. Find out how to set up a new sync domain in the section "Setting up all sync domains".

2. First of all, configure the sync master. Double click on the IO controller that is to be configured as the sync master (in the example, "SIMATIC 300(1)"). Alternatively, select the IO controller and click on the "Properties" button. The "Properties" dialog box of the respective IO controller then opens.
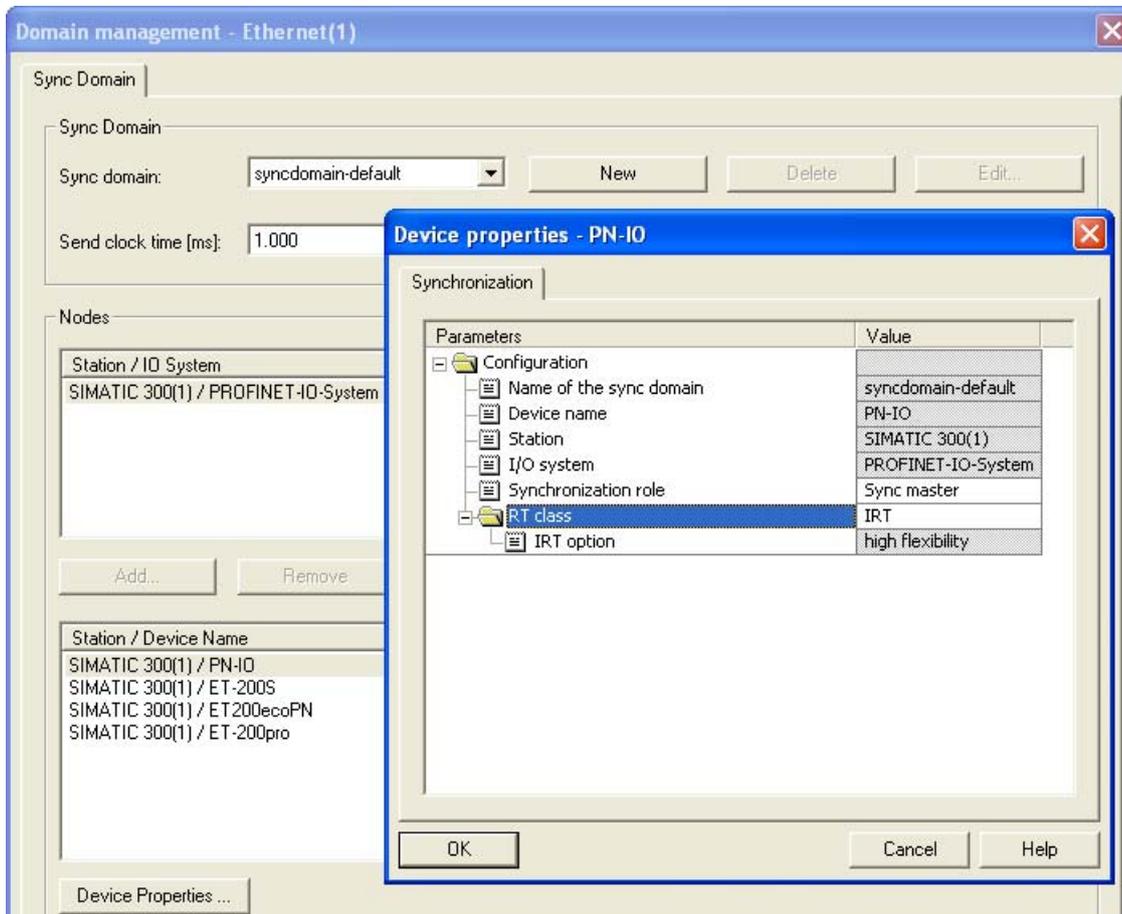
Figure 5-14   Settings for an IO controller for IRT operation

3. Set the synchronization role to "sync master". The RT class automatically changes STEP 7 from "RT" to "IRT".

4. Save the settings and end the "Properties" dialog box with "OK".

5. Now configure the sync slaves. In the "Domain management" dialog box, select the IO devices that are to be configured as the sync slave and then open the "Properties" dialog box of the respective IO device with a double click.

6. Set the synchronization role to "sync slave". The RT class automatically changes from "RT" to "IRT".

7. Adjust the desired IRT option.

8. Save the settings and end the "Properties" dialog box with "OK".

9. Configure the topology if you have selected the IRT option "high performance".

Result: The default sync domain is configured with the PROFINET IO system

The example shows the distributed I/O system ET 200pro that is not to be synchronized. You can configure both synchronized and non-synchronized PROFINET devices in the same PROFINET IO system. The non-synchronized PROFINET device is not a node on the sync domain.

Setting up sync domains

You have the option to configure additional sync domains alongside the default sync domain. The procedure is similar to that for configuring the default sync domain.

Procedure in HW Config

1. Create a new sync domain. Open the "Domain management" dialog box in the shortcut menu of your PROFINET IO system and click on the "New" button. A further sync domain is set up with the default name "sync domain 1" set by the STEP 7.

2. If required, change the name of the sync domain. To do this, click "Edit". The "Edit sync domain" dialog box opens. You can change the default name in this (in the "sync domain new" example).
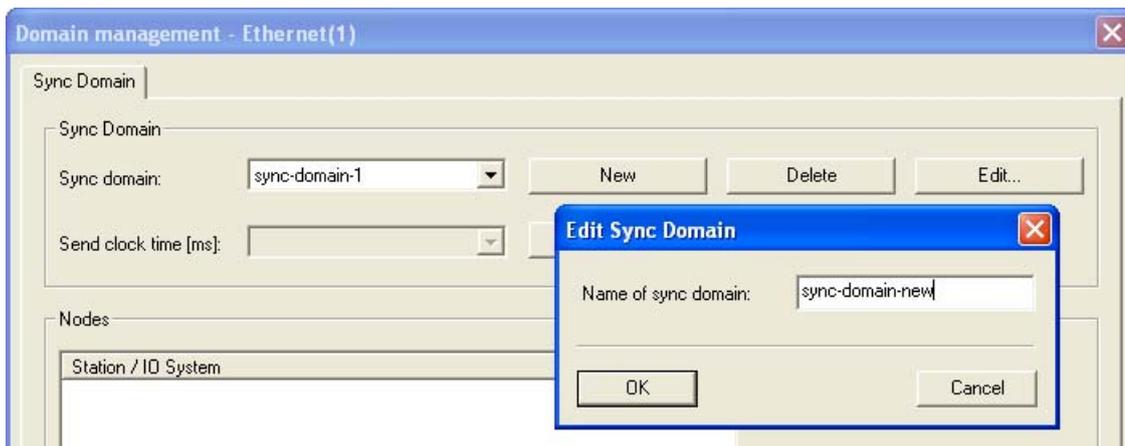
3. Save the settings and close the "Edit sync domain" dialog box with "OK".

4. Add the required PROFINET IO system(s) for the recently set-up sync domain.
   Click "Add" to do this. The "Add station / IO system" dialog box then opens.
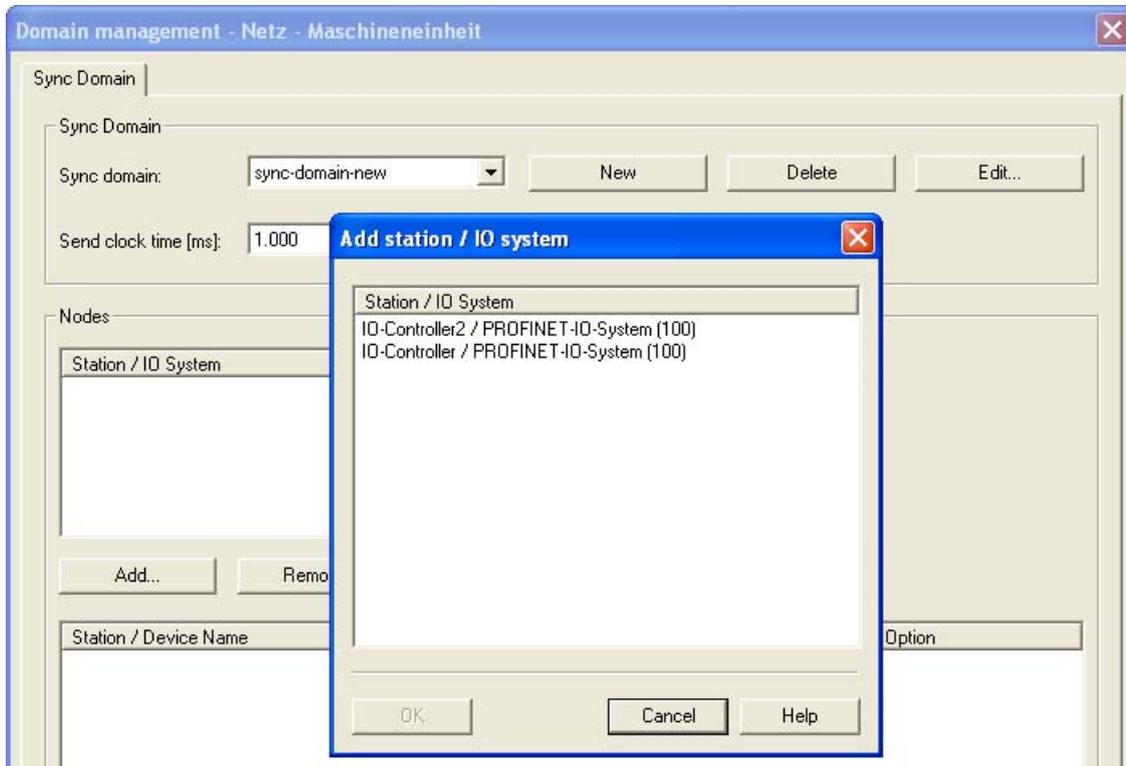
Figure 5-15   IO subsystem on a new sync domain

5. Select the respective PROFINET IO system
(in the "IO controller 2 / PROFINET IO system" example).

6. Save the settings and close the "Add station / IO system" dialog box with "OK".
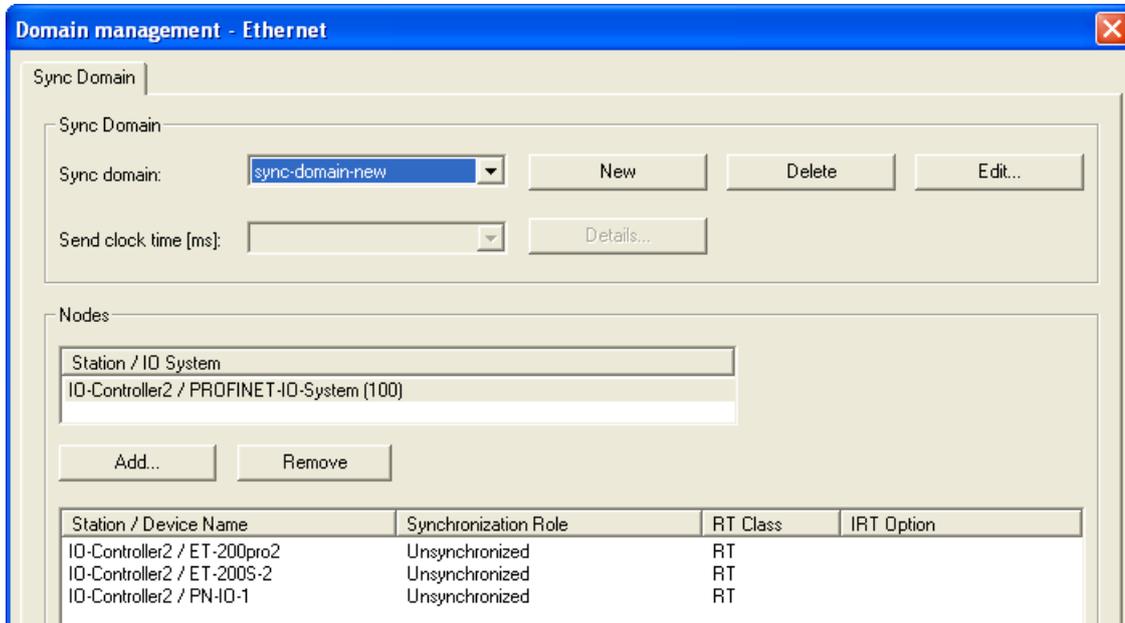
Figure 5-16   PROFINET IO system in sync domain "sync domain new"

Procedure for IRT configuration in HW Config

If required, for each PROFINET device, carry out the settings for the IRT mode.

1. Double click on the IO controller that is to be configured as the sync master.
The "Properties" dialog box of the respective IO controller then opens.

2. Set the synchronization role to "sync master". The RT class automatically changes
STEP 7 from "RT" to "IRT".

3. Save the settings and end the "Properties" dialog box with "OK".

4. Mark all the IO devices that should be configured as sync slaves. Click on the
"Device properties" button. The "Properties" dialog box of the respective IO device
then opens.

5. Set the synchronization role to "sync slave". The RT class automatically changes from
"RT" to "IRT".

6. Adjust the desired IRT option.

7. Save the settings and end the "Properties" dialog box with "OK".

8. Configure the topology if you have selected the IRT option "high performance".

Result: Sync domain new with PROFINET IO system

Save the settings and close the "Domain management" dialog box with "OK".

Deleting the sync domain

Once you have configured further sync domains alongside the available sync domain, you can delete these in the "Domain management" dialog box.

Requirements for deleting

Alongside the standard default sync domain, you have configured at least one further sync domain. In this example, the name of the sync domain that is to be deleted is "syncdomain-new".

Procedure in HW Config

1. Select the **Edit > PROFINET IO > Sync domain management** menu command.

2. In the drop-down list, select the sync domain you want to delete.

3. Click "Delete". PROFINET IO systems of the deleted sync domain will be assigned to the default sync domain "syncdomain-default".

Result: The "syncdomain-default" also contains the PROFINET IO system of the deleted sync domain

Save the settings and close the "Domain management" dialog box with "OK".

NOTICE
Inconsistency on account of two sync masters
After you have deleted the sync domain, the default sync domain with the two PROFINET IO systems also contains two sync masters. As only in each case one sync master may exist in a sync domain, one of the two sync masters must be configured as a sync slave.

See also

Isochronous real-time (Page 67)

5.4.4 Establishing the send clock of the PROFINET IO system

Setting up the send clock

You have the option to establish the send clock for each individual sync domain in order to achieve an optimum coordination of the transmission bandwidth to the data volume. Dependent on the PROFINET devices of the respective PROFINET IO systems, STEP 7 calculates the possible values that can be set.

Prerequisites for setting the send clock

You have already configured a PROFINET IO system or an IO controller.

Procedure in HW Config

1. If the "Domain management" dialog box is not already open, in HW Config select from the shortcut menu of the IO subsystem (railway tracks) the menu command **PROFINET IO Domain Management.**

2. In the "Send clock (ms)" drop-down list, select one of the default send clocks.

3. Save the settings and close the "Domain management" dialog box with "OK".

Result: The PROFINET IO system of the sync domain is established on a send clock

Tip: Optimizing the data transmission

STEP 7 calculates the optimum value for the update time. If you configure individual IO devices with an update time that differs from the default update time, you can set the update time for each individual PROFINET device. The update time corresponds to a multiple of the send clock.

Setting the reserved transmission bandwidth for IRT

You have the option of establishing the reserved transmission bandwidth for IRT data as a proportion of the maximum reservable transmission bandwidth for cyclic user data communication. The proportion is specified in percent (%).

In doing so, the maximum transmission bandwidth set by the system for cyclic data may not be exceeded by the reserved transmission bandwidth for IRT plus the transmission bandwidth that is required for the cyclic data in the free transmission bandwidth (RT communication).

Requirements for setting up the IRT communication traffic

You have already configured the respective PROFINET IO system on a sync domain.

Procedure in HW Config

1. If the "Domain management" dialog box is not already open, then open it. In the HW Config, under the shortcut menu of the IO subsystem (railway tracks), select the menu command **PROFINET IO Domain Management.**

2. Click "Details".

3. In the "Upper limit for IRT" drop-down list, select one of the default values (in %). STEP 7 offers a selection: 0, 10, ... 100.
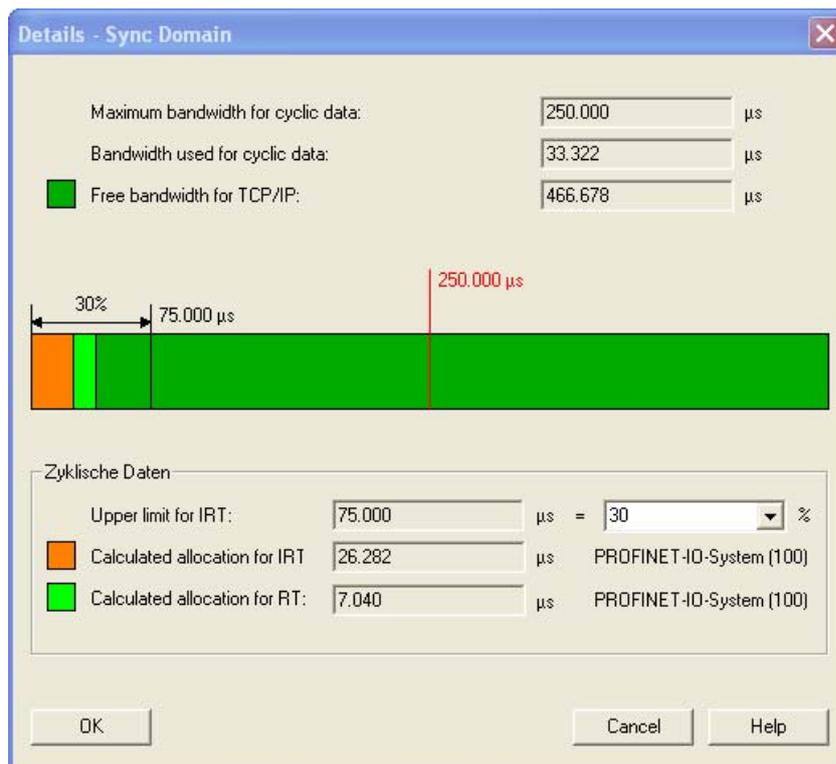
Result: Reserved communication traffic for IRT data

Save the settings and close the "Domain management" dialog box with "OK".

Note

Bandwidth reservation and standard communication

The available transmission bandwidth for the standard communication can be enlarged by reducing the reserved transmission bandwidth for IRT data to the necessary degree. HW Config calculates the required transmission bandwidth for IRT data based on the configuration.

Additional information

You can find additional information on IRT communication in chapter Isochronous real-time (Page 67).

5.5   SIMATIC NCM PC

SIMATIC NCM PC configuration tool

SIMATIC NCM PC is a version of STEP 7 tailored for PC configuration. It offers the full range of STEP 7 functions for PC stations.

SIMATIC NCM PC is the central tool for configuring the communication services for your PC station. The configuration data generated with this tool must be downloaded to the PC station or exported. This makes the PC station ready for communication.

SIMATIC NCM PC and STEP 7 are compatible with one another.

- You can open and edit projects you have created with SIMATIC NCM PC at any time in STEP 7/SIMATIC Manager. where you will find the additional functions for programming and configuring the S7 stations.

- You can open projects you have created with STEP 7/SIMATIC Manager at any time in SIMATIC NCM PC. You can edit existing PC stations and create new PC stations. You can configure the communication links for these PC stations to the existing S7 stations.

NCM PC can use STEP 7 project data

The restrictions in SIMATIC NCM PC relate to the types of station that can be configured. You can only configure and program S7 stations in STEP 7.

The station types that can only be configured in STEP 7 are, however, available as target stations for configuring a connection once the project has been imported into SIMATIC NCM PC.

The OPC server can also use the symbol files created for the S7 stations.
The relevant settings are made when you configure the OPC server.

A project that has been "re-edited" in SIMATIC NCM PC can be opened again in STEP 7 and edited at any time.

STEP 7 provides additional functions for test and diagnostic purposes.

Functions

To configure a PC station, use the following functions:

- Create and configure components of the PC station
- Configure the communication properties of the SIMATIC NET OPC server
- Configure connections
- Adopt the symbols from the SIMATIC S7 configuration
- Configuring DP and PROFINET operation
- Network parameters for operating PROFIBUS and Industrial Ethernet
- Download configuration data to the PC stations
- Store configuration and project engineering data in a file
- Monitoring the communication with connected S7 stations using NCM diagnostics

Additional information

For more detailed information, see the Commissioning industrial communication SIMATIC PC stations - Manual and Getting Started (http://support.automation.siemens.com/WW/view/en/13542666) manual.

See also

SIMATIC PC stations (Page 34)

5.6   Address assignment

5.6.1   Addresses

Addresses

All PROFINET devices are based on the TCP/IP protocol and therefore require an IP address in order to be used on the Ethernet.

To simplify configuring, you will be prompted only once to assign an IP address, namely when configuring the IO controller in STEP 7 / HW Config.

In this case, STEP 7 opens a dialog in which you can select the IP address and the Ethernet network. If the network is isolated, you can accept the IP address and subnet mask proposed by STEP 7. If the network is part of an existing Ethernet company network, obtain the information from your network administrator.

Note

Obtain IP address using a different method

Some CPUs offer the option "Obtain IP address using a different method" in the dialog for setting the IP address. More information about his can be found in chapter:
Different Method to Obtain IP Address / Device Name (Page 221)

The IP addresses of the IO devices are generated by STEP 7 and assigned to the IO devices when the CPU starts up. In addition to this, with independent IO devices, e.g. SCALANCE X, S7 300 CPs, there is option to obtain the IP address not during the startup from the IO controller but already beforehand in a different way (refer to chapter Assigning a device name and IP address (Page 218)).

The IP addresses of the IO devices always have the same subnet mask as the IO controller and are assigned by the IP address of the IO controller in ascending order. The IP address can be changed manually, if necessary.

Device names

Before an IO device can be addressed by an IO controller, it must have a device name. In PROFINET, this method was selected because it is simpler to work with names than with complex IP addresses.

The assignment of a device name for a specific IO device can be compared to setting the PROFIBUS address of a DP slave.

When it ships, an IO device does not have a device name. An IO device can only be addressed by an IO controller, for example for the transfer of project engineering data (including the IP address) during startup or for user data exchange in cyclic operation, after it has been assigned a device name with the programming device/PC .

Note

Obtain device names with a different method

Some CPUs offer the possibility to "obtain device names with a different method". More information about his can be found in chapter: Different Method to Obtain IP Address / Device Name (Page 221)

An exception to this is the PROFINET functionality "Device replacement without removable media / PD" In the case of IO devices for which "Device replacement without removable media / PD" has been configured, the device name of the IO controller is assigned on the basis of the topological configuration.

Alternatively, the device name can be written in the PD directly to the Micro Memory Card.

Structured device names

You can structure the device names using DNS conventions.

These conventions are defined by "Internationalizing Domain Names in Applications (IDNA). According to this, device names are written in lower case.

The "domain name system" (DNS) is a distributed database (http://iana.org), which manages the name space on the Internet. To structure the names, you use the period ("."). The hierarchy is shown in descending order from right to left.

...<Subdomain name>.<Domain name>.<Top-level domain name>

Device number

In addition to the device name, STEP 7 also assigns a device number beginning with "1" when an IO device is plugged in.

This device number can be used to identify an IO device in the user program (for example SFC 71 "LOG_GEO"). In contrast to the device number, the device name is not visible in the user program.

See also

Device replacement without removable media / PD (Page 73)

Configuring a topology (Page 190)

Prioritized startup (Page 75)

5.6.2 IP and MAC address

Definition: MAC address

Every PROFINET device is assigned a worldwide unique device identifier at the factory. This 6-byte long device identifier is the MAC address.

The MAC address consists of:

- 3-byte vendor identifier and
- 3-byte device identifier (consecutive number).

The MAC address is normally printed on the front of the device: e.g. 08-00-06-6B-80-C0.

IP address

To allow a PROFINET device to be addressed as a node on Industrial Ethernet, this device also requires an IP address that is unique on that network. The IP address is made up of 4 decimal numbers with a range of values from 0 through 255. The decimal numbers are separated by periods.

The IP address is made up of the following:

- Address of the network and
- Address of the node (generally called the host or network node).

Subnet mask

The bits set in the subnet mask decide the part of the IP address that contains the address of the network.

In general the following applies:

- The network address is obtained from the IP address AND the subnet mask.
- The node address is obtained by an AND NOT operation on the IP address and subnet mask.

Example of the subnet mask

Subnet mask: 255.255.0.0 (decimal) = 11111111.11111111.00000000.00000000 (binary)

IP address: 192.168.0.2 (decimal) = 11000000.10101000.00000000.00000010 (binary)

Where: the first 2 bytes of the IP address determine the network - i.e. 192.168.
The last two bytes address the node, i.e. 0.2.

Tools for assigning the IP address

You assign the IP address with vendor-specific software, for example STEP 7. You can also assign the IP address for network components using the Primary Setup Tool (PST). A free Download (http://support.automation.siemens.com/WW/view/en/19440762) of the Primary Setup Tool can be found on the Internet. On the Internet, you will also find a list of devices for which the PST is approved.

IP address assignment when replacing an IO controller with removable media / PD

The following is contained on the memory card (removable media, e.g. Micro Memory Card) and the FLASH memory card of the programmable logic controllers (PLC):

- On the IO controller: Device name and IP address

- On the IO device: Device name

The device name is contained on the C-Plug for IE/PB links, PN IO and for switches (in the SCALANCE X series, for example).

The CPs set the IP address on the memory of the CPU. This means that you do not require a C-PLUG for the device exchange.

The device name and the IP address are transferred during the startup of the CPU in the system data block (SDB).

If you remove the memory card / C-Plug from a PROFINET controller and plug it into a different PROFINET device, you will transfer the device-specific information and the IP address to the device.

If an IO device has to be replaced in its entirety due to a device or module defect, the IO controller automatically assigns parameters and configures the new device or module. The cyclic exchange of user data is then restarted. In addition to this, before the network on of the IO device, the Micro Memory Card with the valid name is removed from the faulty IO device and added to the exchanged device.

The MMC card / C-Plug allows modules to be replaced without a programming device/PC in the event of a fault in a PROFINET device. You can also transfer the device data from the PC/PC directly to the MMC (for the ET200S/PN IO device, for example).

IP address assignment when replacing an IO device without removable media / PD

Specific PROFINET devices, like, for example, the distributed I/O ET200 ecoPN, have no module slot on account of their construction type. These PROFINET devices and some others support the PROFINET functionality "Device replacement without removable media / PD" For additional information, see Device replacement without removable media / PD (Page 73).

Default router

The default router is used when data has to be forwarded via TCP/IP to a partner located outside the actual network.

In STEP 7, the default router is named *Router* in the "Properties" dialog box. The "Properties" dialog box is opened with the menu command **Properties Ethernet interface > Parameter > Gateway**. STEP 7 assigns the local IP address to the default router by default.

The router address that is set on the PROFINET interface of the IO controller is automatically transferred for the configured IO device.

5.6.3 Assigning a device name and IP address

Assigning an IP address and subnet mask for an IO controller the first time

There are four options:

1. If your PROFINET device is equipped for a memory card (MMC), plug the MMC into your programming device/PC and save the hardware configuration together with the configured IP address on the MMC. Then insert the MMC into the PROFINET device. When you plug in the MMC, the PROFINET device automatically adopts the IP address.

2. Connect your programming device/PC to the same network as the relevant PROFINET device. The interface of the PD/PC must be set to TCP/IP (Auto) mode. During the download, first of all display all available nodes via the "Available nodes" download dialog box. Select the target device via its MAC address and then assign its IP address before you download the HW configuration including the configured IP address (IP address is saved retentively).

3. If your PROFINET device has an MPI or PROFIBUS DP interface, connect your programming device/PC directly to the PROFINET device via the MPI or PROFIBUS DP interface. From STEP 7, assign an IP address to the device (actually assigned when the hardware configuration is downloaded).

4. Assignment of the IP address "with a different method": The addresses can be assigned through STEP 7 "Edit Ethernet participant", the primary setup tool or also through the user program (SFB104).

Assigning device names for IO devices where the PROFINET Function "Device replacement without removable media / PD" has been configured.

For IO devices that already have the PROFINET Function "Device replacement without removable media / PD" configured, it is not necessary to assign the device name in the case of a device replacement. For additional information, see Device replacement without removable media / PD (Page 73).

Commissioning a PROFINET interface

Further details of how to commission a PROFINET interface can be found in the operating instructions for the PROFINET devices from the SIMATIC family.

Assigning a device name and address for an IO device (exception in the case of PROFINET Function device exchange without media change/PG)

The following graphic illustrates the process for assigning the device name and address.
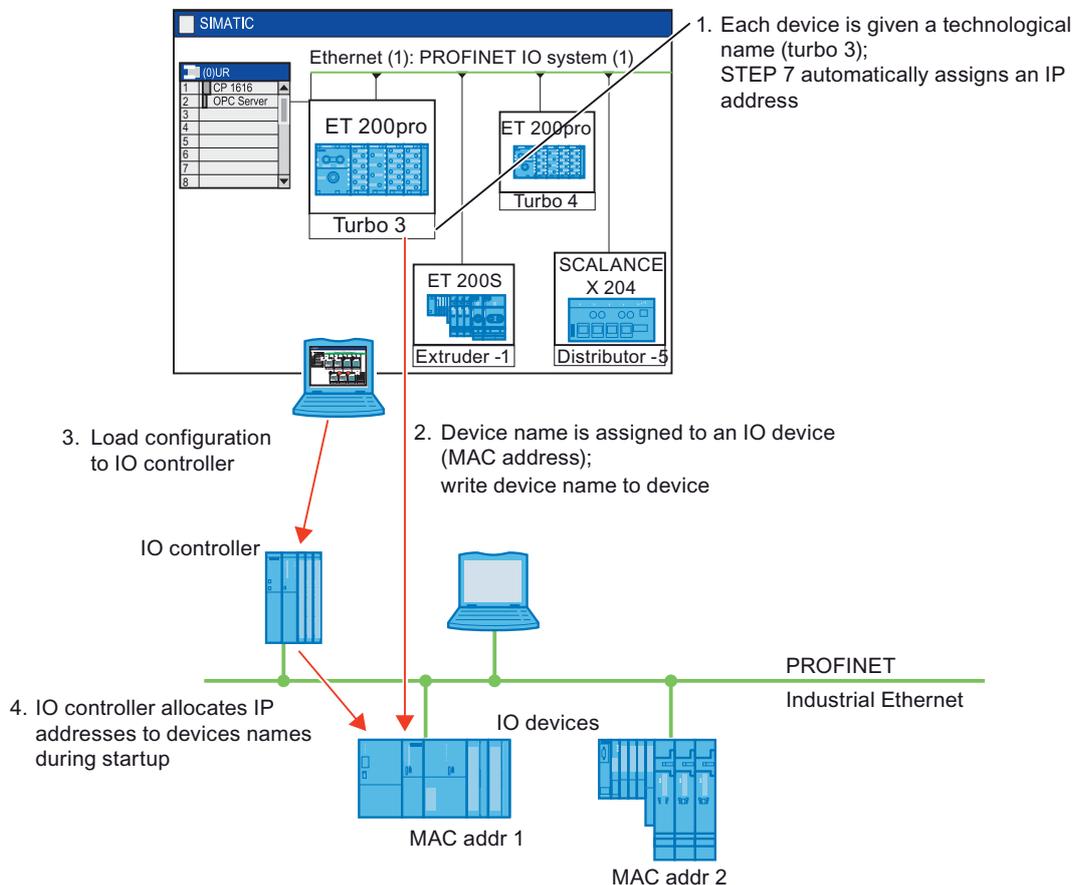
Figure 5-17   Principles: Assigning the device name and address

In STEP 7, a device name is assigned to every IO device. You can change the name and IP address manually.

You have two options for downloading configured data to the PROFINET device:

1. Offline with a Micro Memory Card:

   Place the configured data (device name: e.g., Turbo 3) for the IO device in the MMC in the PD/PC. Do this using the STEP 7 "Save device name to memory card" function. Then insert the MMC into the PROFINET device. The device automatically adopts the configured device name.

2. Online with programming device/PC:

   Connect the programming device/PC directly to the Ethernet subnetwork via the PROFINET interface. In STEP 7, use the MAC address of the respective IO device to select and download the configured data (device name, e.g. Turbo 3) to the PROFINET device.

   The IO controller recognizes the IO device by its device name and automatically assigns the configured IP address to it.

Tip: Identification of the PROFINET device in the control cabinet

PROFINET IO devices must be assigned a device name when they are started for the first time. In STEP 7 / HW Config, you can make the LINK LED of a PROFINET IO device you are naming flash using **PLC > Ethernet > Assign Device Name**. This allows you, for example, to clearly identify the PROFINET IO device among several identical devices in a control cabinet.

Assigning device names for IO devices where the PROFINET Function "Device replacement without removable media / PD" has been configured

If an IO device supports the PROFINET Function "Device replacement without removable media / PD" and this function is configured in the IO controller, then, from the default neighbor relationships established from by the set topology and actual neighborhood relationships established from the real PROFINET devices, the device can identify the IO controller without names and then assign the configured name and the configured IP address and record it in the user data traffic (refer also to chapter Device replacement without removable media / PD (Page 73)).

IP address assignment for special IO devices

Special IO devices, e.g. SCALANCE X, S7 300 CPs, support the option of assigning the IP addresses not from the IO controller during startup. In this case, the IP address is assigned in a different way. For additional information, refer to the manual of the respective PROFINET device of the SIMATIC device family.

Requirements for extra procedures for assigning IP addresses

If the IO device, as described above, should not obtain the IP address from the IO controller, then proceed as follows:

- Download your project to the HW Config.
- Open the "Properties" dialog box for the respective PROFINET device.
- Disable the "Assign IP address via IO Controller" check box under the "General" tab.

Note

IP address with IO device and IO controller

The IP address for the subnetwork of the IO device must comply with the IP address of the IO device.

Extra procedures for IP address assignment

- NCM PC
- CLI
- BOOTP
- PST (Primary Setup Tool)
- DHCP

See also

IP and MAC address (Page 216)

Addresses (Page 214)

5.6.4   Different Method to Obtain IP Address / Device Name

Introduction

Special applications such as mass produced machines or print feeders require new methods for obtaining the device names and IP addresses. The background here is the desire for a machine that can be commissioned locally at the customer's facility without needing STEP 7 or other tools.

Options for assigning IP addresses and device names

Apart from the known address and device name assignment in the "General" and "Parameters" tabs of the PN IO interface, there are three other ways in which the IP address and name can be obtained:

- Assignment by the user program through SFB 104.
- Assignment when downloading the configuration to the target system in the "Select Node Address" dialog box.
- Assignment by the menu command: **Target system > Ethernet > Edit Ethernet Node** or through the primary setup tool.

Procedure

- Device name: Select the "Use different method to obtain device name" check box on the interface of the PROFINET device.
- IP address: Select the "Use different method to obtain IP address" check box on the "Parameters" tab of the Properties - Ethernet Interface dialog.

Note

Gateway

If the "Use different method to obtain IP address / device name" is used in a PROFINET device, the corresponding PROFINET device cannot be used as gateway.

5.6.5   Retentivity of IP address parameters and device names

The retentivity of IP address parameters and device names depends on how the assignment occurred. The non-retentive, temporary assignment means:

●   IP address parameters and device names remain valid until the next NETWORK OFF or permanent deletion. After NETWORK OFF / NETWORK ON or permanent deletion, the CPU is only accessible through the MAC address.

●   Loading a temporary IP address also deletes the retentive, saved IP address parameter.

Retentivity behavior depending on the assignment method

Assignment of IP address parameters and device names		Retentivity
Standard method: Fixed assignment in STEP 7	IP address parameter / device name if assigned during configuration in *STEP 7*. With the loading of the configuration on the CPU, the IP address parameter / device name are also saved in the CPU.	Data are retentive: ● with POWER OFF / POWER ON ● after permanent deletion ● after deleting the configuration (SDBs) ● after removing the MMC
Fixed assignment of settings "Different method for obtaining IP address parameter / device name"	IP Address parameter / device name are assigned through DCP (**D**iscover and **C**onfiguration **P**rotocol): ● Through a setup tool like PST or in *STEP 7* , for example, through "Edit Ethernet Node". ● Through the higher-level IO controller if the CPU is operated as an I-device with a prioritized startup.	
Temporary assignment in STEP 7	IP Address parameter / device name are assigned through DCP (**D**iscover and **C**onfiguration **P**rotocol): ● With an automatic IP address assignment through "Reachable nodes" in *STEP 7*, if the CPU does not yet have an IP address.	Data is **not** retentive:
Temporary assignment of the setting"Different method for obtaining IP address parameter / device name"	IP Address parameter / device name are assigned through DCP (**D**iscover and **C**onfiguration **P**rotocol): ● With the IP address assignment through the higher-level controller to the I-device if the I-device is **not** run with a prioritized startup.	
Assignment in the user program	IP address parameter / device name are assigned in the user program through SFB 104. The retentivity of the IP address parameter / device name can be determined in the corresponding parameter dataset.	Retentivity corresponding with the determinations in the parameter dataset

Resetting the IP address parameters and device names

Retentive IP address parameters and device names can be reset as follows:

- Through "Reset to factory settings"

- Through a Firmware update

NOTICE
• Through the temporary assignment of IP address parameters / device names, a reset of retentively saved IP address parameters/device names occurs.   • With a fixed assignment of IP address parameters/device names, previously retentively saved parameters are replaced with the newly assigned parameters.

NOTICE
Reuse of devices
Execute the "Reset to factory settings" before you install a device with retentive IP address parameters / device names in different subnetworks / systems or before you place it in storage.

5.7 Diagnostics in PROFINET IO

Content of this section

This chapter contains the following information:

- How the diagnostics mechanism in PROFINET IO works
- Diagnostics support by STEP 7 / NCM PC
- Evaluation of the diagnostics message in the user program
- Diagnosing the network infrastructure
- Diagnosing from the LED states of a PROFINET interface

Diagnostics overview

You can proceed as follows for the diagnostics:

- Respond to an error (event-driven diagnostics, evaluation of interrupts)
- Check the current status of your automation system (status-driven diagnostics)

Just like PROFIBUS DP, PROFINET IO also has various options.
The following table lists the most important options for accessing diagnostic information.

Table 5- 1   Diagnostics overview

Diagnostic options	Benefits	You will find the information in section...
Online diagnostics with a programming device/PC/HMI device	This allows you to evaluate the current status of your automation system.	Support by STEP 7/NCM PC (Page 228)
Reading system status lists (SSLs) in the user program	The SSLs will help you to track down an error.	Evaluation of Diagnostics in the User Program (Page 233)
Reading diagnostic data records	You can obtain detailed information about the type and source of faults by reading the diagnostic data records.	Evaluation of Diagnostics in the User Program (Page 233)
Signaling of system errors	Diagnostics information is displayed in the form of messages on the HMI device or web server.	Support by STEP 7/NCM PC (Page 228)
SNMP	With this protocol, you can run diagnostic checks on the network infrastructure	Network infrastructure diagnostics (SNMP) (Page 237)
Diagnostic interrupt	This is used to evaluate diagnostics in the user program	Evaluation of Diagnostics in the User Program (Page 233)
Web server	Diagnostic information can be comfortably retrieved in a standard web browser.	Diagnosing using the web server (Page 237)

See also

Status and error indicators: CPUs with PN interface (Page 236)

5.7.1 Basic principles of the diagnostics in PROFINET IO

Totally Integrated Diagnostics Concept

PROFINET IO supports you with an integrated diagnostics concept.

The basics of this concept are explained below.

Basic concept

Each individual error or several errors occurring concurrently are transferred from the IO device to the IO controller.

If you require the full status of the IO device including any pending errors, you can also read the status directly from the IO device.

Extended maintenance concept

The PROFINET interfaces with integrated switch of the SIMATIC devices support the four-stage diagnostics concept. This is based on the PROFINET Specification V2.1, "Application Layer services for decentralized periphery and distributed automation" and "Application Layer protocol for decentralized periphery and distributed automation".

Table 5- 2   Classification of the diagnostics status

Diagnostic status	Symbol		Severity of the error
Good	Green circle	●	low
Maintenance required (Maintenance required)	Green wrench	🔧	
Maintenance demanded (Maintenance demanded)	Yellow wrench	🔧	
Bad	Red circle	●	high
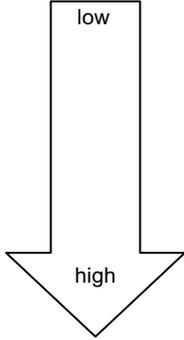
The aim of the diagnostics concept is the early detection and elimination of potential faults - before they cause a production outage.

Other status information is defined in addition to the Good (no fault) and Bad (fault) status information for a PROFINET device.

The maintenance information is generated with the following system alarms:

● Maintenance required (symbolized by a green screwdriver) and

● Maintenance demanded (symbolized by a yellow screwdriver)

The times at which the two system alarms are generated can be customized for most wear parameters. Some parameters, such as the attenuation on a fiber optic cable, are defined in the PROFINET specification, version 2.1 or later.

Diagnostic levels

You can analyze diagnostic information at different levels.
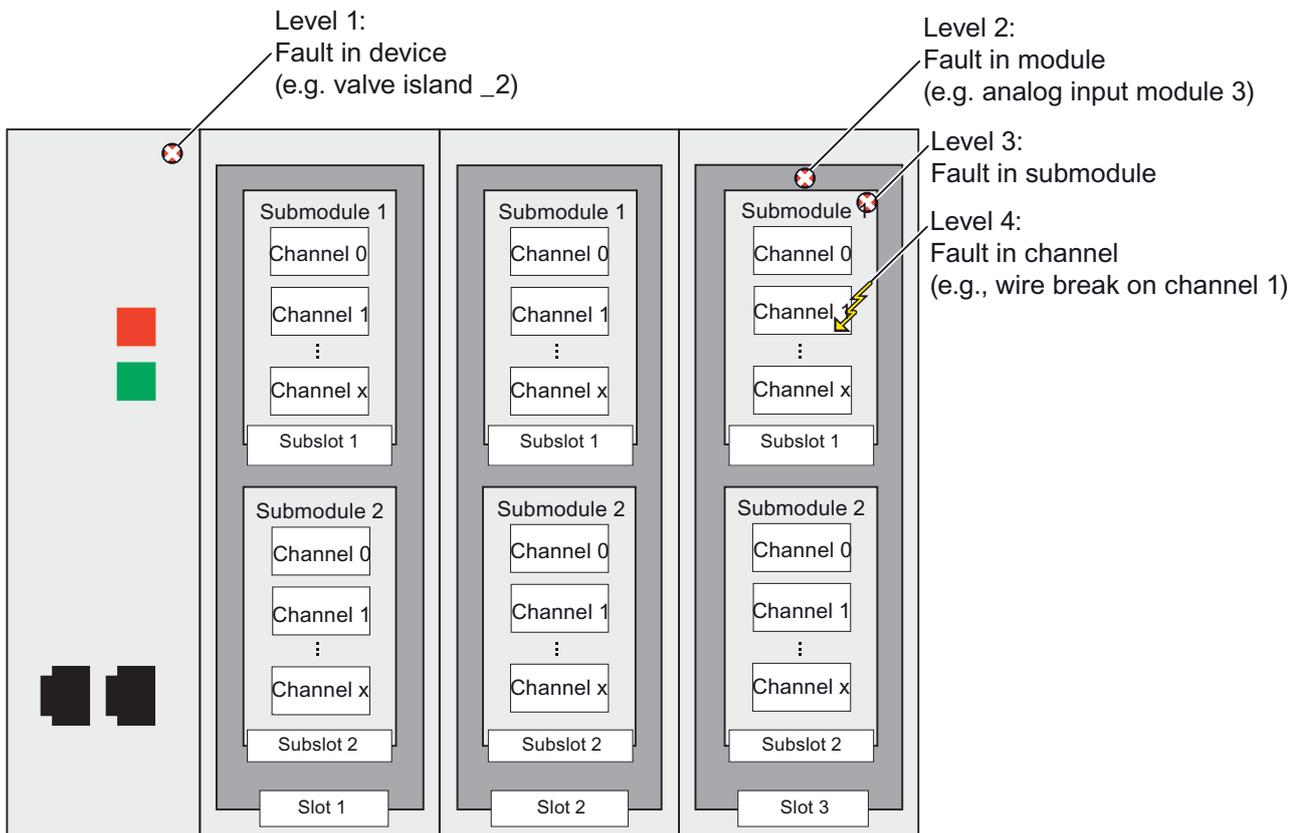
Figure 5-18   PROFINET IO diagnostic levels

Accessing the status of an IO device with a programming device or an operator control and monitoring device

If you are connected to the Industrial Ethernet via a programming device with STEP 7 or an operator control / monitoring device, you can also call up diagnostics information online. This is illustrated by the following graphic.

Number	Description
①	Online diagnostics in STEP 7 or operator control and monitoring device: The programming device / operator control and monitoring device (PG/HMI) requests the station status of the IO device.
②	Following the request from the programming device/PC/HMI, the IO controller automatically reads the entire station status asynchronously directly from the IO device and stores the read diagnostic information in system status lists on the IO controller. The programming device/PC/HMI then accesses these system status lists.
③	Online diagnostics in STEP 7 or operator control and monitoring device: The PG / PC / HMI can also read the station status directly from the IO device without the IO controller being involved (e.g. in the life list). This is only possible if the programming device/PC/HMI is connected directly to the Industrial Ethernet.
	This means that you can access diagnostic information during the commissioning phase or for servicing even if the IO controller is not operational.

Figure 5-19   PROFINET IO diagnostics with STEP 7 or operator control / monitoring device

More detailed information on diagnostics in PROFINET IO

For more detailed information, see the From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) programming manual.

For more detailed information, refer to the STEP 7 online help, version V5.4 SP1 or higher.

5.7.2 Support by STEP 7/NCM PC

Diagnostics in STEP 7 / NCM PC

The following graphic illustrates the various diagnostic options in STEP 7.

For diagnostics with NCM PC, the devices must support the Simple Network Management Protocol (SNMP). The diagnostics steps are applicable accordingly for NCM PC as in STEP 7.
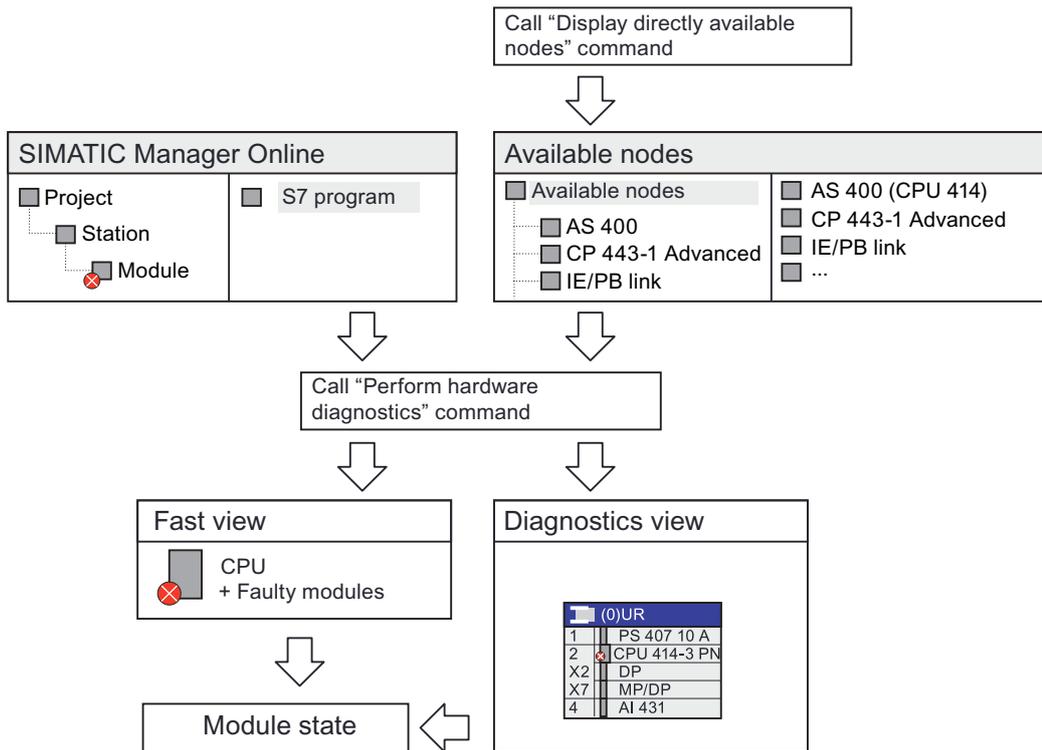
Figure 5-20   Diagnostics in STEP 7

HW Config Online

The online view in HW Config provides an overview of the current status of your system in STEP 7. It also shows the configuration information (for example non-configured modules). To use these functions in STEP 7 / HW Config, select the menu command **Station > Open Online**.

Schematic drawing of the station view:
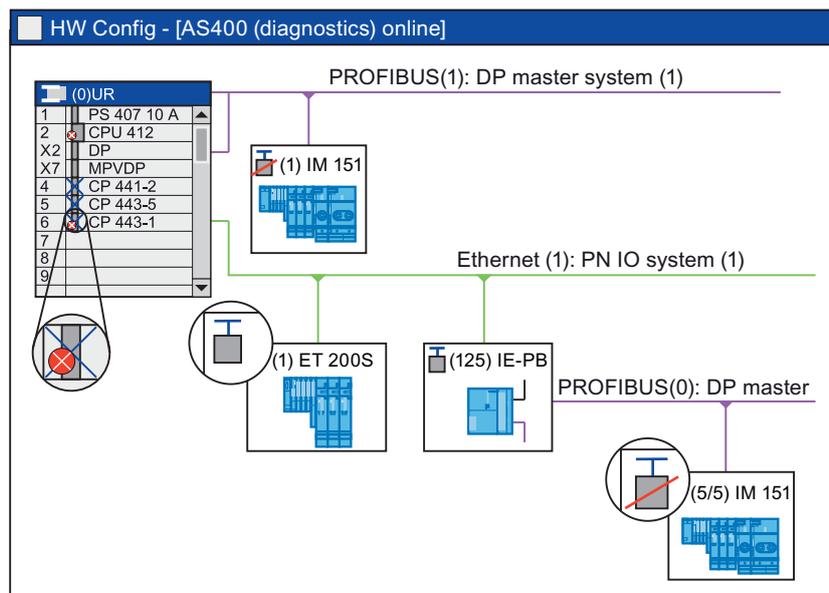
Figure 5-21   Online view in HW Config (Schematic illustration)

Additional information on configuring "Report system error"

"Report system error" is also supported by PROFINET IO.

The STEP 7 Function "Report system error" provides a convenient way to display diagnostics information provided by the component in the form of messages.

STEP 7 automatically generates the necessary blocks and message texts. The user only needs to load the generated blocks on the CPU and transfer the texts to connected HMI devices.

Displaying available nodes

In SIMATIC Manager, you can use the **Display available nodes** menu command to display a list of PROFINET devices.

Note

The interface of the PG/PC must be set to Ethernet in STEP 7/NCM PC. Otherwise, no connection can be established.

Diagnostics view and fast view

In STEP 7, you can display an overview of the modules in which faults have occurred by running the following command in SIMATIC Manager: **PLC > Diagnostics/Settings > Hardware Diagnostics**.

The STEP 7 settings allow you to decide whether the fast view or the diagnostics view should be displayed by default.

In the **fast view**, the IO controller (CP or CPU) and the faulty modules.

In the **diagnostics view**, all modules are displayed.

Module information

Detailed diagnostics information is displayed in the "Module information" window. You can see the following information in this window:

- Device status (OK, maintenance requested, maintenance required, faulty, failed)
- Device name (for example, valve_1)
- Device type (for example ET 200S)
- Fault location (slot, module, submodule, channel)
- Channel error type (wire break for example)
- Remedy with troubleshooting (for some modules)

STEP 7/NCM PC

NCM integrated into STEP 7 provides comprehensive diagnostic options for the various types of communication in PROFINET.

You can start NCM diagnostics from the **Start > SIMATIC > STEP 7 > NCM S7** menu or in the "Properties" dialog box of a CP.

5.7.3 Examples of diagnostics mechanisms

Diagnosing communication processors and switches

The following graphic illustrates the important basics of diagnostics for communication processors and switches.
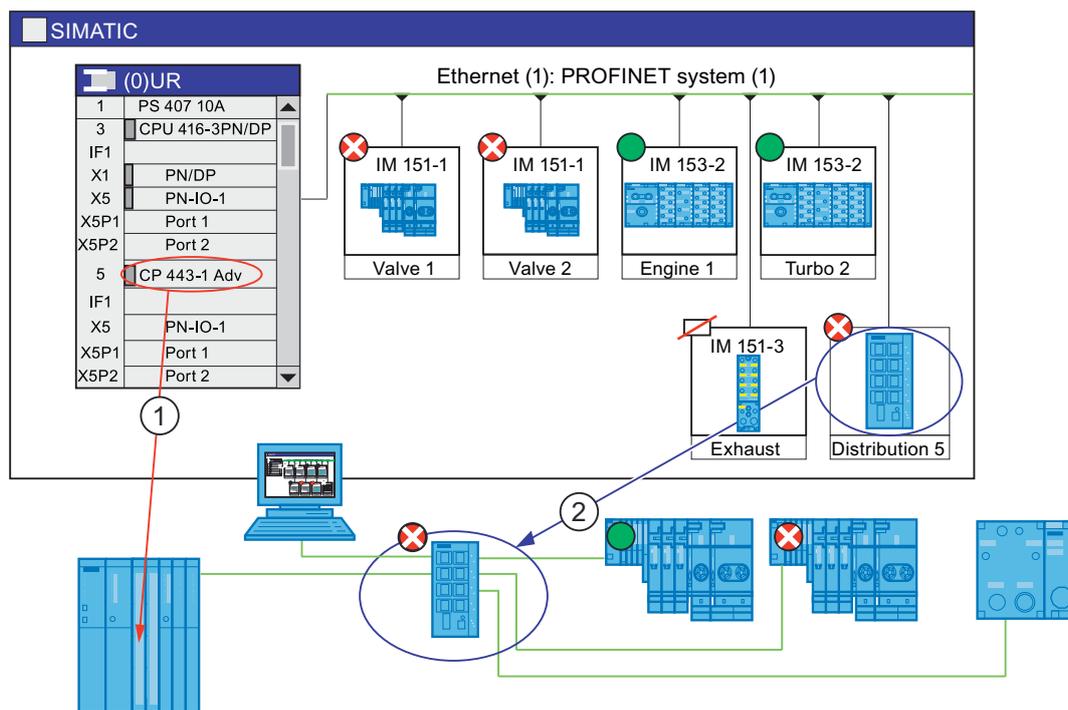
Number	Meaning
①	Diagnostic checks for a communication processor (CP)
②	Diagnostic checks for a switch

Figure 5-22   Communication processors and switches

Diagnosing communication processors

A communication processor provides exactly the same diagnostics in STEP 7 as the PROFINET interface of a CPU. This applies to all communication processors used as the PROFINET interface in a PC (number ①, previous image).

Switch

If a switch (for example, SCALANCE X 200/400) supports PROFINET IO and is integrated in the configuration like a field device, you can run diagnostics on this switch like a field device in STEP 7 (number ②, previous image).

Some switches (e.g. SCALANCE X 200/400) also provide the option of web-based diagnostics with the aid of web-based management.

Sequence of diagnostics for a wire break

The following graphic illustrates how diagnostics information is exchanged when the transmission quality on the optical cable decreases due to ageing, for example. In this example, the scenario is considered after a maintenance required has already been diagnosed.

- – – – Fiber-optic cables

──── Copper cables

Number	Description
①	The system reserve of the fiber-optic cable drops below 0 dB.
②	Both the ET 200 S PN FO and the switch send the maintenance demand alarm to the IO controller.
③	Based on the interrupts, the IO controller detects the maintenance requested from the switch and from the device. The module information data is updated in the IO controller and the corresponding error OBs are called. Note: To be able to start the error OBs in the IO controller, the "OB 82 / Periphery Fault Task - Call in response to communication alarm" property for the IO controller concerned must be selected in STEP 7.
④	In STEP 7 (on the programming device/PC), the maintenance demanded message is indicated on the device and at the switch by a yellow wrench symbol.
⑤	STEP 7 can also read detailed information directly from the switch.

Figure 5-23   Sequence of the diagnosis

5.7.4 Evaluation of Diagnostics in the User Program

Diagnostics as for PROFIBUS DP

The diagnostic options provided by STEP 7 for PROFIBUS DP components are also available for PROFINET IO. The procedure is essentially the same.

Diagnostics in the user program

The evaluation of diagnostic information using SFBs/SFCs in the user program is similar to that in PROFIBUS DP.

In PROFINET IO, there is a vendor-independent structure for data records with diagnostic information. Diagnostic information is generated only for channels on which a fault has occurred. With PROFINET, there are two ways to obtain diagnostic information.

1. Evaluating the diagnostic status

If you would like to find out the current status of your automation system, read the system status lists (SSLs), which provide an overview of the available IO systems. You can use the SSLs to locate faulty stations or stations at which maintenance is requested or required within an IO system.
You can use partial lists to narrow the fault down to one module/submodule.
SFB 52 (Read data record) is then used to read various diagnostic records directly from the module concerned and thus obtain detailed information about the error.
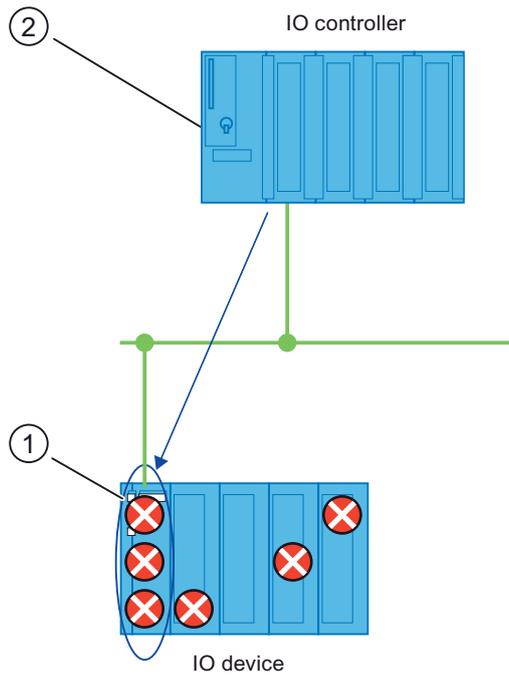
Number	Description
①	All individual errors are collected in a single record on the interface module.
②	In your user program, SFB 52 reads the entire station status asynchronously directly from the IO device.

Figure 5-24   Example: Evaluating diagnostic interrupts with SFB 52

2. Evaluation of interrupts

If an error/interrupt occurs, an error organization block (error OB) is called automatically. The OB number and the start information already provide information about the cause and location of the error. You can obtain detailed information about the error event in this error OB using SFB 54 (Read additional interrupt information).
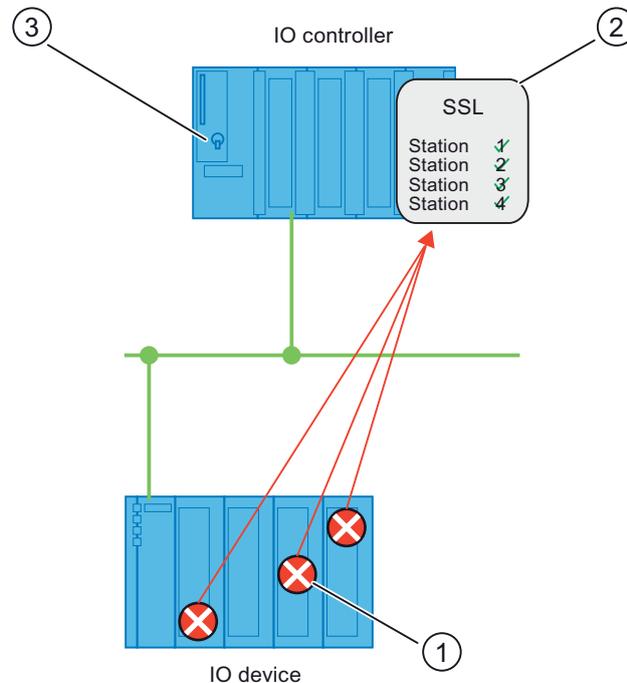
Number	Description
①	Every error is sent to the IO controller individually as channel diagnostic information in the form of an interrupt.
②	In the IO controller, the module information data is updated automatically and the error OB (OB 82) is started.
③	In your user program in the error OB (OB 82), SFB 54 reads the error synchronously from the IO controller without addressing the IO device.

Figure 5-25   Diagnostics with OB 82 and SFB 54

PNIODiag diagnostics package

With the PNIODiag diagnostics package you are given the possibility of simply evaluating diagnoses of I/O modules. This diagnostics tool can be used with equal effect both in the PROFIBUS DP as well as in the PROFINET IO. For information about components and functions, refer to Internet (http://support.automation.siemens.com/WW/view/en/26996747).

Diagnostics with SFC 51 "RDSYSST" and SFB 54 "RALARM" and "Signal system error"

Example applications and diagnoses in the user program are available on the Internet Application Portal (http://support.automation.siemens.com/WW/view/en/24000238) of Automation and Drives, Service & Support.

Diagnostic records in PROFINET IO

There are two different types of diagnostic record:

1. Channel diagnostic records

   Channel diagnostic records are displayed when there is an error on a channel and/or the channel has triggered an interrupt. If there is no error, a diagnostic record of length 0 is returned.

   Up to 400 channel errors can be displayed at one time.

2. Vendor-specific diagnostic records

   The structure and size of vendor-specific diagnostics records depend on the vendor's settings. This information is entered in the GSD file of a device. The GSD file is supplied by the device vendor.

List of diagnostic records

For information on this, refer to the From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) programming manual.

Comparison of the diagnostics between PROFINET IO and PROFIBUS DP

For information on this, refer to the From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) programming manual.

For information on SFBs and OBs, refer to the STEP 7 Online Help and the System Software for S7-300/400 System and Standard Functions (http://support.automation.siemens.com/WW/view/en/1214574) manual.

5.7.5   Status and error indicators: CPUs with PN interface

Status and error indicators: PROFINET devices

With the aid of the status and error indicators of the LEDs of the PROFINET device, you can diagnose errors in conjunction with the communication or the error statuses of the PROFINET module.

Additional information on diagnosing via LEDs

For additional information on diagnosing with the aid of the status and error displays of the LEDs, refer to the respective manual for the PROFINET device in question.

5.7.6 Diagnosing using the web server

Diagnostics options

Depending on the functionality of the CPU of the S7 family, with the integrated web server you have available the following diagnostics possibilities:

- Start page with general CPU information
- Identification data
- Contents of the diagnostic buffer
- Module information
- Messages (without acknowledgment option, provided this was generated before)
- Information about communication
- Topology
- Variable status
- Variable tables

More information on web servers

For additional information on web servers, refer to the manual of the respective S7 CPU.

5.7.7 Network infrastructure diagnostics (SNMP)

Availability

As an open standard, you can use any SNMP-based systems or software solutions for diagnostics in PROFINET.

Network diagnostics

SNMP (Simple Network Management Protocol) makes use of the connectionless UDP transport protocol. It consists of two network components, similar to the client/server model. The SNMP manager monitors the network nodes and the SNMP agents collect the various network-specific information in the individual network nodes and stores it in a structured form in the **MIB** (Management Information Base). This information allows a network management system to run detailed network diagnostics. Access to SNMP data from PROFINET devices is generally read only, except for a small amount of data that is not production-relevant.

MIB

An MIB (Management Information Base) is a data base of a device. SNMP clients access this data base in the device. The S7 device family supports, among others, the following standard MIBs:

- MIB II, standardized in the RFC 1213

- LLDP MIB, standardized in the international standard IEE 802.1AB

- LLDP PNIO-MIB, standardized in the international standard IEE 61158-6-10

MIB II

SNMP MIB II is designed for the diagnostics of the network interface and provides information on the "Network health" of the node. Additional information, such as the operating status of the CPU, group errors, can be queried via the standard PROFINET diagnostics mechanisms.

Detecting the network topology

LLDP (Link Layer Discovery Protocol) is a protocol that is used to detect the closest neighbors. It enables a device to send information about itself and to save information received from neighboring devices in the LLDP MIB. This information can be looked up via the SNMP. This information allows a network management system to determine the network topology.

Integrating HMI devices via the SNMP OPC server

Configuration of the OPC server is integrated in the STEP 7 hardware configuration application. The communication with the OPC server is carried out without an S7 connection. You therefore do not need to configure S7 connections.

Stations that have already been configured in the STEP 7 project can be transferred directly. As an alternative to STEP 7, the configuration can also be run with the NCM PC (included on the SIMATIC NET CD) or can be determined automatically and transferred to the project configuration.

Use of SNMP in the SIMATIC NET environment

SNMP-compliant devices from the SIMATIC NET family can be monitored and operated via a conventional standard Internet browser.

The management system known as web-based management offers a range of device-specific information (network statistics, status of redundant supply, for example).

Diagnostics with the SIMATIC NET SNMP OPC server

The SNMP-OPC-Server software facilitates diagnostics and parameter assignment actions on any SNMP device, even including HMI devices which cannot read SNMP variables from other devices.

The OPC server uses the SNMP protocol to exchange data with these devices.

All information can be integrated into OPC compatible systems such as the HMI system WinCC. This enables process and network diagnostics to be combined in the HMI system.

Uses of SNMP

SNMP can be used as follows:

- By users to integrate network diagnostics into a central HMI / SCADA system using the SNMP OPC server.

- By the IT administration of machines and plant owners to monitor their Industrial Ethernet network using standard network management systems.

- By the IT administration, to primarily monitor the office network, but often also the automation network using standard network management systems
  (for example, HP Open view).

Additional information

Information relating to SNMP in the network management standardization group can be found at Internet (http://www.snmp.org).

Additional information on SNMP can be found on the Internet (http://www.profibus.com).

Additional information on SNMP OPC servers can be found on the Internet
(http://www.automation.siemens.com/net/html_76/produkte/040_snmp.htm).

PROFINET CBA - Engineering

6

Content of this section

This section provides you with more detailed information about PROFINET CBA (Component Based Automation). Here you will find the following information:

- How does the basic engineering sequence run from start to finish?
- What are the PROFINET components and technological functions?
- What devices do PROFINET components consist of?
- What diagnostics options are available?

6.1 Engineering with SIMATIC iMap

Engineering concept of SIMATIC iMap

PROFINET offers you a standardized device and vendor-independent engineering interface in SIMATIC iMap. This allows you to easily integrate devices and components from different vendors into a single plant via PROFINET.

SIMATIC iMap allows you to bring together distributed automation applications in a graphical format so that they can be displayed for the entire plant. All the necessary PROFINET components are available to you in a uniform representation in a library.

The communication connections between the devices do not have to be programmed, and can be configured graphically as interconnection lines.

SIMATIC iMap can download the contents of the PROFINET components and the associated interconnections to devices in the plant. During commissioning and operation, you can use SIMATIC iMap to look up process and the diagnostic data from the devices and to modify parameters and project data for testing purposes.
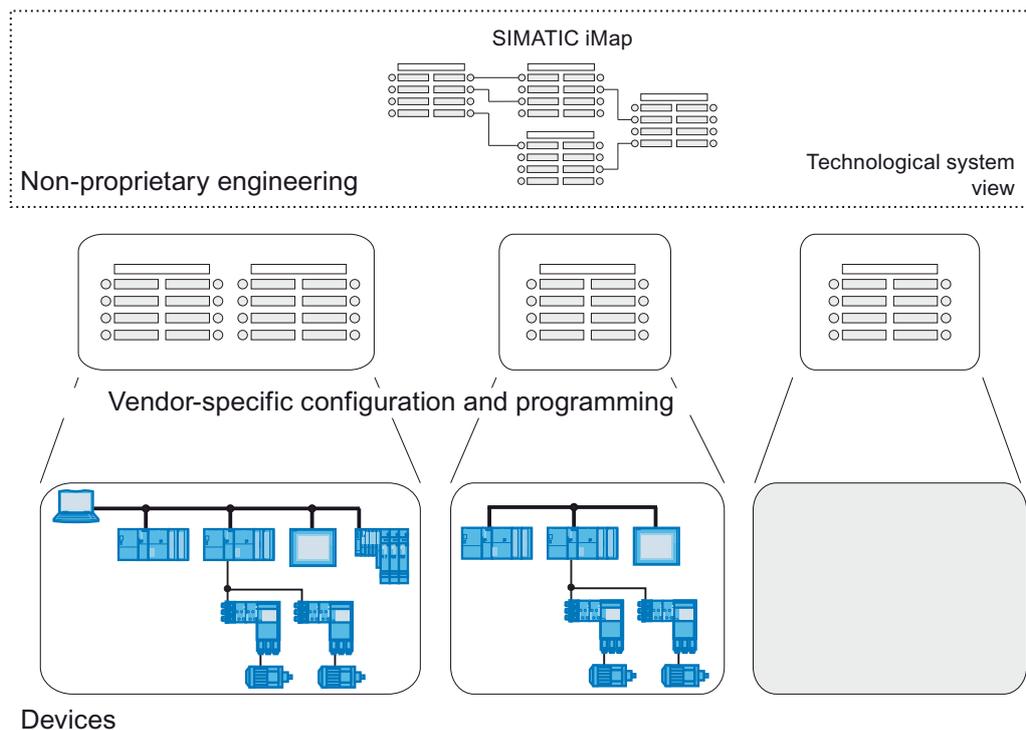
Figure 6-1   SIMATIC iMap engineering concept

Vendor- and device-independent engineering concept

SIMATIC iMap provides the following functions for interfacing with vendor-specific configuration and programming tools:

● Software for integrating PROFINET components that contain SIMATIC automation systems and were programmed in STEP 7.

● Access to vendor-specific tools for device configuration and diagnostics.

Basic steps from planning to operating a plant

Setting up and operating a plant with SIMATIC iMap involves the following basic steps:

1. Planning the system

   The system planner specifies the following:

   – Required functions

   – Applicable automation systems and field devices

   – Functions that can be combined to create reusable technological modules

   – Necessary technological interfaces and interaction between PROFINET components and required variables for diagnostics and visualization

2. Creating PROFINET components

   The system and mechanical engineer creates the PROFINET components using the vendor-specific configuration and programming tool (for SIMATIC automation systems: STEP 7). It must also carry out the following tasks:

   – Configure the hardware and set the parameters

   – Create technological interface descriptions

   – Create user programs

   – Test technological modules

   – Create PROFINET components (XML file and associated data storage)

   – Optional: Import PROFINET components into a SIMATIC iMap library.

3. Configuring the plant in SIMATIC iMap

   The configuration engineer creates the project in SIMATIC iMap by carrying out the following steps:

   – Opening existing library or creating new library

   – Importing new PROFINET components into the library, if required

   – Inserting PROFINET components into the project

   – Networking devices in the network view

   – Assigning addresses to the devices: IP address / subnet mask or IP address gateway, address and / or PROFIBUS address (this step depends on the device)

   – Interconnecting the technological functions in the plant view

   – Changing properties of devices and functions

   – Checking the configuration

   – Documenting and archiving the project

4. Commissioning and testing the plant

   The commissioning engineer performs the following tasks:

   – Commissioning individual devices

   – Downloading project data to the devices of the system

   – If required, re-editing devices and technological functions in the vendor-specific engineering system

   – Testing the system

   – Creating symbol data for access via OPC

5. Operating the plant.

   The plant operator performs the following tasks:

   – Monitoring and manipulating process data online (vertical integration)

   – Running diagnostics on the plant

   – Operator control and monitoring

   – Performing maintenance and modifications.

PROFINET Component Description (PCD)

You generate a component in your engineering system (STEP 7, for example).
The engineering system saves the PROFINET component description as an XML file.
You can import this XML file into SIMATIC iMap and interconnect it with other components.
For additional information, refer to the Configuring SIMATIC iMap systems
(http://support.automation.siemens.com/WW/view/en/22762190) manual.

Support from SIMATIC IMap

SIMATIC iMap supports you from the planning stage through to operation of a plant as follows:

- Data management of your own and off-the-shelf PROFINET components in libraries

  PROFINET components that you have created or obtained off-the-shelf can be managed in libraries whose content you decide yourself.

- Interconnecting technological functions in the plant view

  In the plant view, you can position technological functions graphically, interconnect them, and look up/modify their properties.

- Networking devices in the network view

  In the network view, you can link devices to a PROFIBUS or Industrial Ethernet subnet graphically and assign the relevant addresses.

- Monitoring and modifying variables online

  You can access the process data online at any time. You can either use a variable table, integrate HMI devices such as WinCC flexible into your system, or use OPC-based client programs.

- Running diagnostics on PROFINET devices and technological functions

  The current status of the PROFINET devices and technological functions is displayed continuously in a separate diagnostics window. With an online-offline comparison, you can determine whether or not it is necessary to download the programs and/or interconnections.

- Presentation of the project in a hierarchical tree structure

  All parts of the system are represented in a clearly identifiable way that allows convenient navigation and other management functions in the project.

- Automatic creation of plant documentation

  SIMATIC iMAP automatically creates full documentation for the configured plant, including all devices, technological functions and their connections as well as the graphical representation of the networking and interconnections.

- Checking the configuration

  You can check the configuration in SIMATIC iMap even before you generate the project from the device-specific performance data.

- Looking up online device data

  With the online device analysis, you can look up online data of individual devices for test and diagnostic purposes.

- Version control for PROFINET components

Assigning the IP address

You must assign the IP address using the vendor-specific software. The method for assigning an IP address with STEP 7, for example, is explained in chapter IP and MAC address (Page 216).

CPU communication

With PROFINET CBA, communication between the CPUs as components is either cyclic or acyclic.

6.2   Component concept

Overview

Mechanical, electrical, and electronic parts of automation systems handle certain technological functions in the automation system or the manufacturing process.

All the parts of automation systems that belong to a technological function form an independent technological module together with the associated control program.
If this technological module meets the communication requirements of the PROFINET specification, it is possible to create a PROFINET component from it in an engineering system.

Example of transport

The above definitions are shown in the following graphic with reference to an example called "transport":
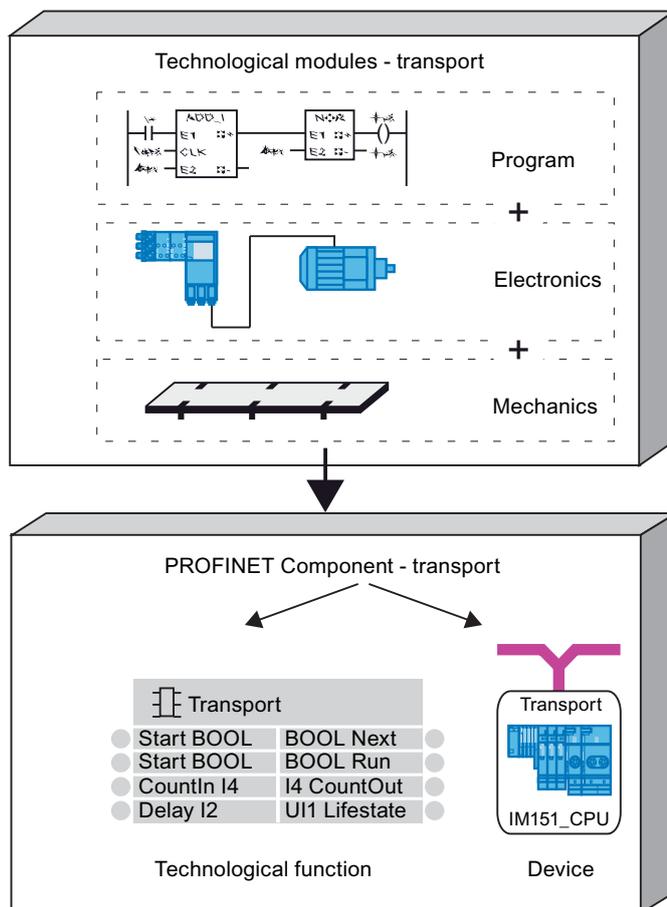
Figure 6-2   From the technological module to the PROFINET component

PROFINET component

A PROFINET component incorporates all the hardware configuration data, the module parameters and the associated user program for use in PROFINET CBA. The PROFINET component is made up as follows:

- Technological function

  The (optional) technological (software) function includes the interface to other PROFINET components in the form of interconnectable inputs and outputs.

- Device

  The device is the representation of the physical programmable controller or field device, including any I/O, sensors and actuators, the mechanical system and the device's firmware.

Libraries and instances

You can store PROFINET components in a SIMATIC iMap library for later reuse. If you reuse PROFINET components, you simply need to adapt them to the new situation (instantiate).

How are PROFINET components created?

Configure and program the programmable controller or field device of the PROFINET component using the device vendor's configuration and programming tool (for example, STEP 7).

Then create a PROFINET component, for example with a menu command, from the configuration of the programmable controller and its user program. This encapsulates the functionality of the device with the application-specific programs. From the outside, only the technological interfaces (component interfaces) are accessible. These are needed for the interaction across the machine or plant, diagnostics, visualization, and vertical integration.

The component interfaces of the PROFINET components are described in XML (Extensible Markup Language) and stored in an XML file. This is created in STEP 7, for example, with the PROFINET interface editor. XML allows information to be represented in a cross-platform and vendor-independent format. The structure of the XML file is specified in the PROFINET engineering model.

The device-specific information about the hardware configuration and the user program, if necessary, can be included in the PROFINET component.

Advantages of PROFINET components

By using PROFINET components you can benefit from the following technological properties together with the following advantages:

- Modularization and reusability

  The concept of the PROFINET components allows extensive modularization of automation systems. PROFINET components can be reused as often as required in different automation solutions.

- Totally integrated communication by supporting the PROFINET specification

  Regardless of its internal functionality, each PROFINET component provides a standardized interface for communicating with other components via Industrial Ethernet or PROFIBUS. The PROFINET specification describes the open communication interface for PROFINET-compliant devices.

- Vendor-independent engineering

  The technological functions of individual devices are programmed in the vendor-specific engineering tools. However, vendor-independent engineering tools such as SIMATIC iMap are used for the plant-wide interconnection of technological functions. This allows products from different vendors to be integrated into the PROFINET communication. Vendors of field devices and programmable controllers simply have to upgrade their programming and configuration tools to interface with the device-independent engineering tool.

Programmable and fixed functionality

The application-specific functionality of an intelligent device is determined by the user program that can be downloaded to the device. Simpler devices such as drives or field devices do not have their own user program. The functionality of these devices is integrated in their firmware. We distinguish between the following PROFINET components:

- With programmable functionality

  The component contains its own user program that can be downloaded to the device from SIMATIC iMap.

- With fixed functionality

  The component does not have its own user program (for example standard DP slaves).

Additional information

If you are using the SIMATIC iMap tool for the first time, then Getting Started Getting Started with SIMATIC iMap (http://support.automation.siemens.com/WW/view/en/22761964) will help you to start using the tool.

If you want to configure PROFINET CBA, you will find comprehensive and easy-to-understand instructions in the Configuring SIMATIC iMap systems (http://support.automation.siemens.com/WW/view/en/22762190) manual.

If you want to work through some SIMATIC iMAP tool exercises, then you will find an easy-to-understand publication with various exercises in the Commissioning SIMATIC iMap systems (http://support.automation.siemens.com/WW/view/en/22761971) tutorial.

The Creating SIMATIC iMap STEP 7 AddOn PROFINET components (http://support.automation.siemens.com/WW/view/en/22762278) manual gives you more information on setting up DBA components.

6.3 Diagnostics for PROFINET CBA

Diagnostics in SIMATIC iMap

In SIMATIC iMap, diagnostic information on process variables and problems in the technological functions, the devices, and interconnections are displayed in three tabs in the diagnostics window.

Additional information on diagnostics with SIMATIC iMap

For additional information, open the online help of SIMATIC iMap.

You will find an application example illustrating diagnostics in the Component based Automation manual *Getting Started with SIMATIC IMap* in the chapter Step 9: Diagnostics.

See also

Getting Started with SIMATIC iMap
(http://support.automation.siemens.com/WW/view/en/22761964)

PROFINET - configuration example

7

7.1 PROFINET IO - configuration example

7.1.1 PROFINET IO system

Functions of PROFINET IO

The following graphic shows the new functions in PROFINET IO.
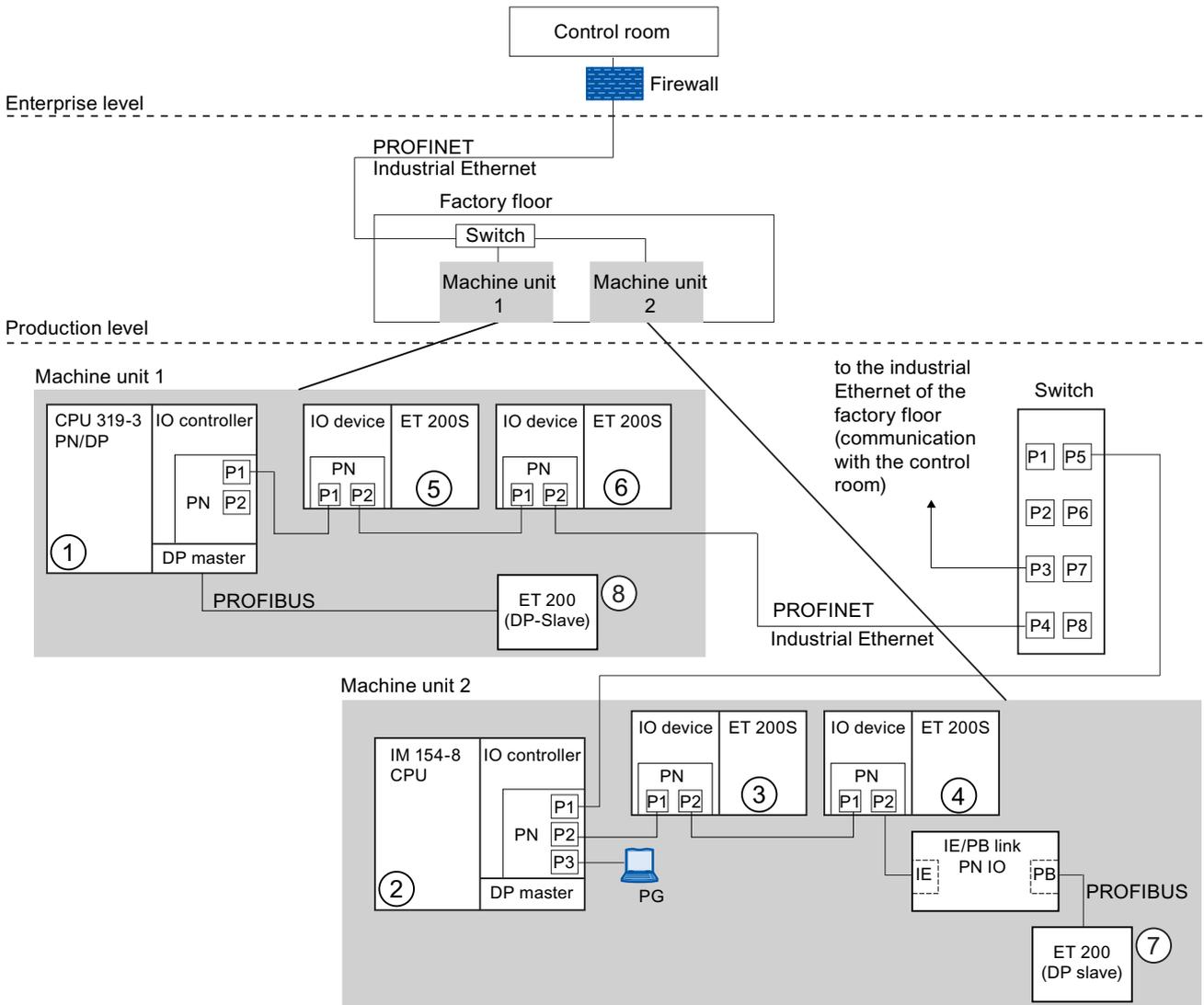
The graphic shows	Examples of connection paths
The connection of the company management levels and production levels	You can use PCs to access devices at the production level in your control room Example: • PC (control room) - switch - IO devices ET 200S ⑤ + ⑥ - CPU 319-3 PN/DP ①.
The connection of the automation system of the machine unit 1 and machine unit 2	You can, of course, also access other areas on the Industrial Ethernet from a PG at the field level. Example: • PC - integrated switch IM 154-8 CPU ② - switch - on IO device: ET 200S ⑥.
The IO controller of the IM 154-8 CPU ② **directly** controls devices on the Industrial Ethernet and PROFIBUS.	At this point, you can see the extended IO features between the IO controller and IO device(s) on the Industrial Ethernet: • The IM 154-8 CPU ② is operated as an IO controller for the two IO devices ET 200S ③ and ET 200S ④ • The IM 154-8 CPU ② is also the IO controller for ET 200 (DP slave) ⑦ by way of IE/PB link.
The CPU 319-3 PN/DP ① can be operated as IO controller or DP master	Here you can see that a CPU can be both the IO controller for an IO device and the DP master for a DP slave: • The 319-3 PN/DP CPU ① is operated as IO controller for the IO devices ET 200S ⑤ and ET 200 S ⑥ • The CPU 319-3 PN/DP ① is the DP master for a DP slave ⑧. The DP slave ⑧ is assigned locally to the CPU ① and is not visible on the Industrial Ethernet.

Additional information

For more detailed information on PROFINET, refer to the From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) programming manual. This manual also provides a clear overview of the new PROFINET blocks and system status lists.

7.1.2 PROFINET IO system with IRT

Example of a PROFINET IO system with IRT
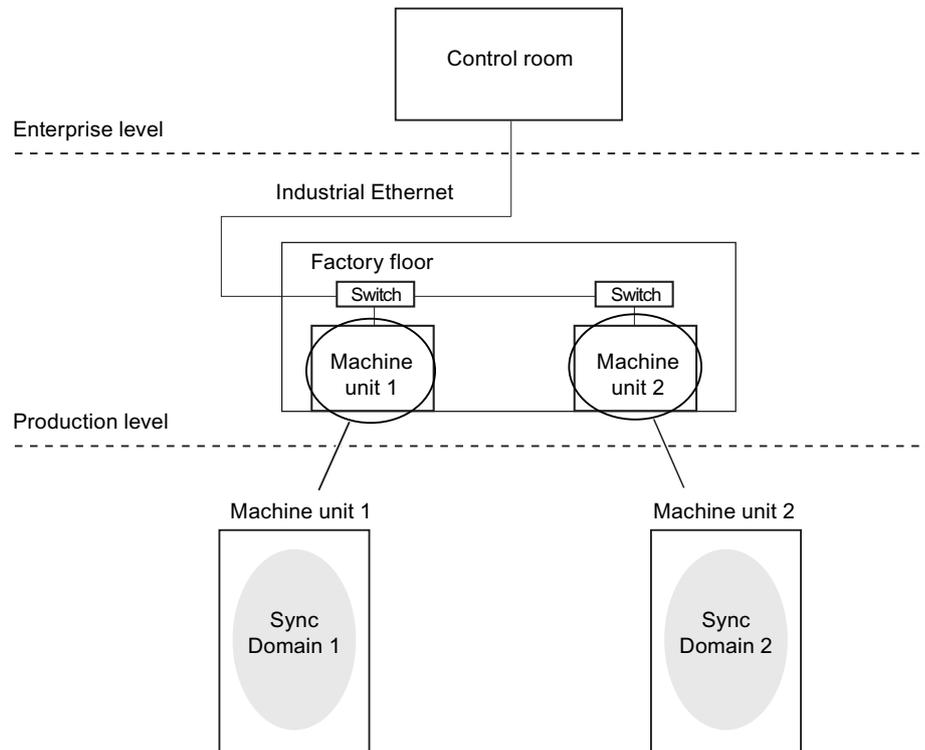
Figure 7-1   PROFINET IO system with IRT - overview

The graphic illustrates an interconnection of several machine units in the PROFINET IO
system with IRT. The machine units with their sync domains in each case consist of one or
more PROFINET systems.

Detailed view of machine unit 1
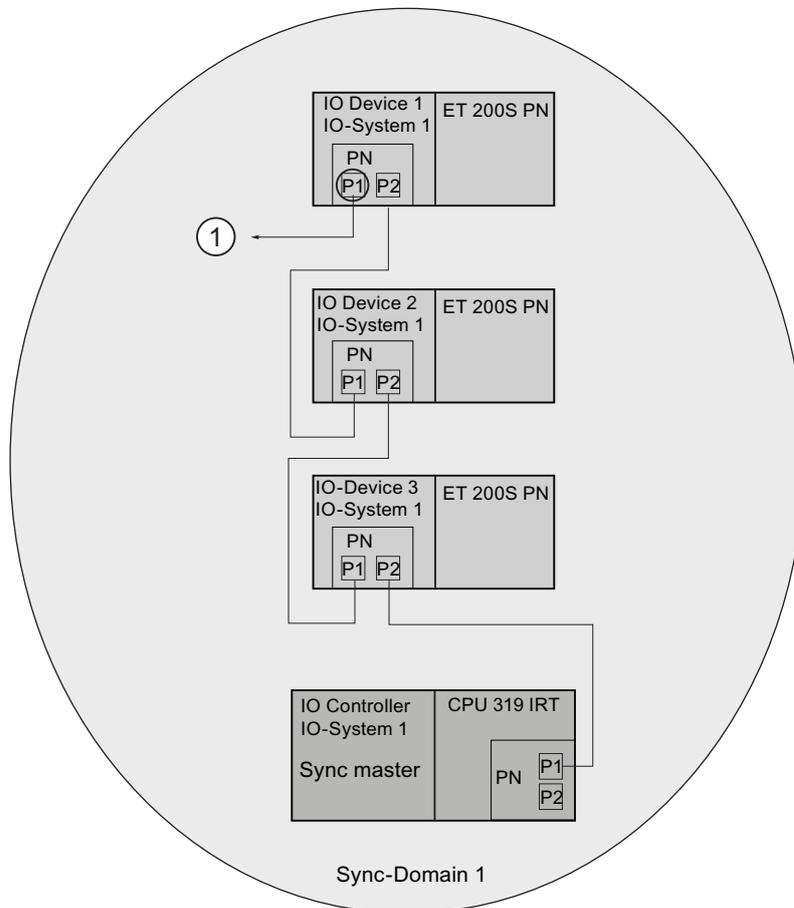
P1	Sync-Domain boundary for port 1 configured	
1	to the industrial Ethernet of the factory floor (communication with the control room and with other machine units/sync-domain)	

Figure 7-2   Machine unit 1

The communication network of machine unit 1 consists of an IO controller and several IO devices. The PROFINET devices in sync domain 1 have the following functions:

● The IO controller of the PROFINET IO system 1 serves as a sync master that synchronizes all further PROFINET devices in the sync domain 1. IO devices are configured as sync slaves.

● The machine unit 1 is connected with the other machine units / sync domains via the free ports of the IO device 1.

● The sync domain boundary is configured for the port 1 of the IO device 1 in order to demarcate the synchronization in view of the other sync domains.

● All PROFINET devices in sync domain 1 are synchronized.

Detailed view of machine unit 2
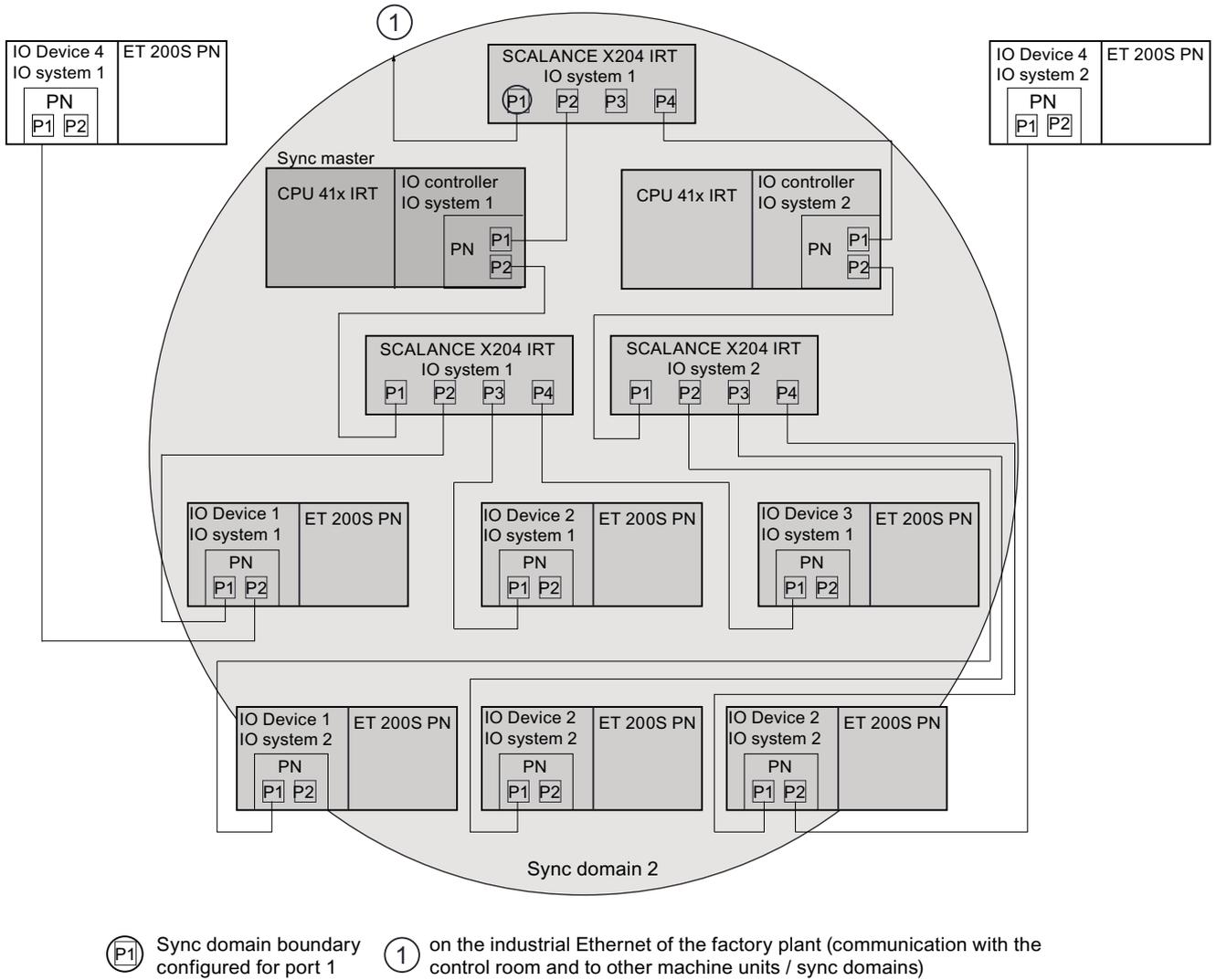
Figure 7-3   Machine unit 2

The communication network of machine unit 2 consists of two PROFINET IO systems and in each case one IO controller, several IO devices and several switches. The PROFINET devices in sync domain 2 have the following functions:

- The IO controller of the PROFINET IO system 1 serves as a sync master that synchronizes all further PROFINET devices in the sync domain 2. The IO devices, the IO controller of the PROFINET IO system 2 and the switches are configured as sync slaves.

  In principle, you can operate several IO controllers simultaneously in one and the same sync domain. You should also configure an IO controller as sync master and all additional PROFINET devices as sync slaves.

- With sync domain boundaries you are capable of operating several sync domains on one and the same network. They are configured for the respective ports the PROFINET devices of which produce a communication connection to PROFINET devices of other sync domains. In this example configuration, the machine unit 2 is connected with the other machine unit / sync domain via the switch of the PROFINET IO system 1 via port 1. The sync domain boundary is configured for this port of the switch.

- All PROFINET devices in sync domain 2 are synchronized.

- Non-synchronized PROFINET devices of a PROFINET IO system must be arranged topologically outside of the sync domain. In this example, the IO devices 4 in the PROFINET IO system 1 and IO devices 4 in the PROFINET IO system 2 are not synchronized and arranged outside of the sync domain.

7.2   Application example PROFINET IO and PROFINET CBA

We shall now demonstrate just how flexible PROFINET really is.

Configuration in SIMATIC iMap

The graphic shows a possible configuration of components in SIMATIC iMap.
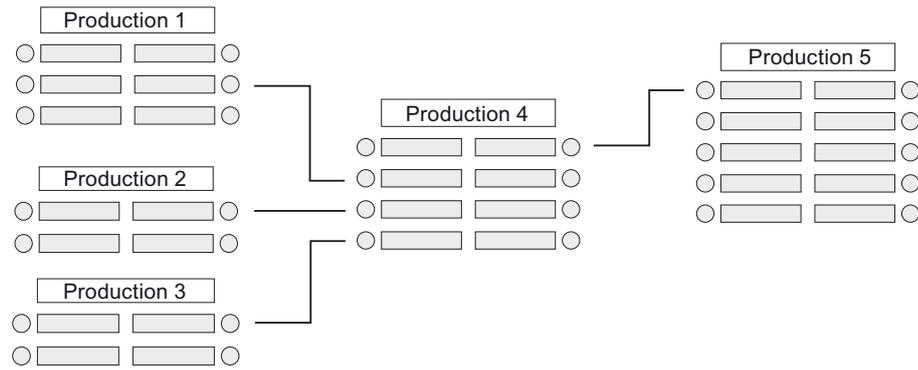
Figure 7-4   Example - Configuration in SIMATIC iMap

Real technical interconnection

Technically, these components can be set up, put together, and interconnected completely differently to the way illustrated in the following graphic.
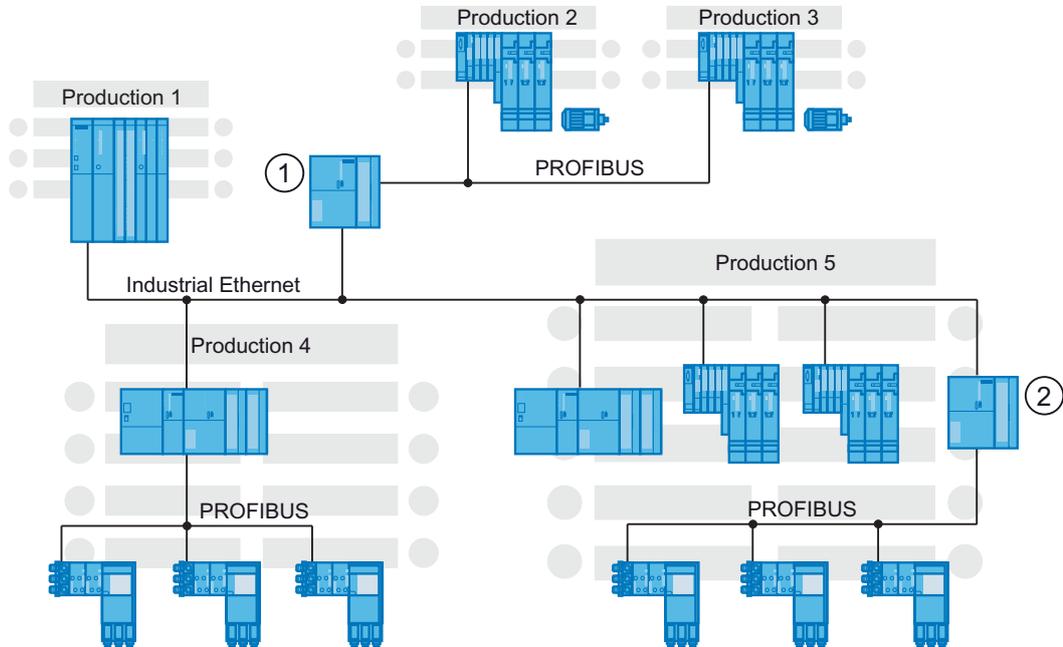
Number	Description
①	IE/PB link for PROFINET CBA
②	IE/PB link PN IO for PROFINET IO

Figure 7-5   Example - Implementation

"Production 1" component

These components consist of a PROFINET controller with central I/O, e.g. S7 400 with CP 443-1 advanced.

"Production 2" and "Production 3" components

Each of these components consists of an intelligent PROFIBUS device.
Both devices are connected to PROFINET via an IE/PB link, e.g. ET 200S CPU.

In this case, the IE/PB link ① for Component Based Automation, as a PROFINET device with proxy functionality, is the proxy for the PROFIBUS nodes. The IE/PB link ① represents each connected PROFIBUS DP slave as a separate component on the PROFINET.

"Production 4" component

This component consists of a PROFINET controller as a PROFIBUS DP master to which distributed PROFIBUS DP slaves are connected. The PROFIBUS and the DP slaves are not visible in SIMATIC iMap, e.g. CPU 317-2 PN/DP or PC with PROFIBUS CP and WinLC software.

PROFINET IO components "Production 5"

The largest component in the system consists of a PROFINET IO controller (for example, CPU 317-2 PN/DP) and the PROFINET IO devices assigned to it. The PROFINET IO devices are connected directly to the Industrial Ethernet. There are also additional PROFIBUS devices connected via an IE/PB link.

In this case, the IE/PB link ② for PROFINET IO, as a PROFINET device with proxy functionality, is the proxy for the connected PROFIBUS nodes. The IE/PB link ② represents each connected PROFIBUS DP slave as a PROFINET IO device on the PROFINET.

Communication between PROFINET IO controllers and PROFIBUS devices is entirely transparent.

Summary: IE/PB link for Component Based Automation and IE/PB link for PROFINET

Note the differences between the IE/PB link for CBA and the IE/PB link for PROFINET IO.

In Component Based Automation, the IE/PB link for CBA ① represents each connected PROFIBUS DP slave as a component on the PROFINET.

In PROFINET IO, the IE/PB link for PROFINET IO ② represents each connected PROFIBUS DP slave as a PROFINET IO device on the PROFINET.

Advantages of CBA and SIMATIC iMap as a plant-wide engineering system

In SIMATIC iMap, the various components can be connected easily and conveniently across the entire plant. This simplifies engineering by the following points:

- The type of communication system depends on the real device
- Independency in the configuration of the communication
- Independency from the type of I/O (central or distributed)

Note

CBA und IRT

You can only use the advantages of CBA and IRT with the option "high flexibility".

Appendix A

A.1 Information sources for PROFINET

The following tables contain important sources with information that goes beyond the scope of this manual.

General Information

Table A- 1 General information about PROFINET

Information	Source
General information about PROFINET	Internet pages on PROFINET (http://www.automation.siemens.com/profinet/index_00.htm)
Standards and background knowledge concerning PROFINET and PROFIBUS	Internet pages on PROFINET and PROFIBUS (http://www.profibus.com)
Basic terminology and basics of communication, communication functions	Manual Communication with SIMATIC (http://support.automation.siemens.com/WW/view/en/1254686)
Active and passive network components, structure of networks, configuring and setting up communication networks	Manual S7-400 automation system, installation (http://support.automation.siemens.com/WW/view/en/1117849)
	Manual S7-300 CPU 31xC and CPU 31x: Installation (http://support.automation.siemens.com/WW/view/en/13008499)
	Manual Windows Automation Center RTX WinAC RTX 2009 (http://support.automation.siemens.com/WW/view/en/38016351)
	Manual Embedded Automation S7-modular Embedded Controller (http://support.automation.siemens.com/WW/view/en/37971572)
	Manual S7-CPs for Industrial Ethernet - Configuring and Commissioning (http://support.automation.siemens.com/WW/view/en/8777865)
	Manual SIMATIC NET Twisted Pair and Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736)

Information	Source
Topology	Manual SIMATIC NET Twisted Pair and Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736)
	PROFINET Installation Guideline (http://www.profibus.com/nc/downloads/downloads/profinet-installation-guide/display/) of the PROFIBUS user organization
Industrial Ethernet	STEP 7 Online Help
	S7-300 CPU 31xC and CPU 31x, Technical Data (http://support.automation.siemens.com/WW/view/en/12996906) Equipment Manual
	SIMATIC NET IO Base User Programming Interface (http://support.automation.siemens.com/WW/view/en/19779901) Programming Manual
Component Based Automation PROFINET CBA	Commissioning Component Based Automation Systems (http://support.automation.siemens.com/WW/view/en/18403908) Tutorial
	Getting Started Component Based Automation, Commissioning Systems (http://support.automation.siemens.com/WW/view/en/18403688)
	Manual Configuring systems in SIMATIC iMap (http://support.automation.siemens.com/WW/view/en/8131230)

Special topics

Table A- 2   Special topics associated with PROFINET

Information	Source
PROFINET IO and PROFIBUS DP • Differences and common features • From PROFIBUS DP to PROFINET IO • User programs • Diagnostics	From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) Programming Manual
New and modified blocks and system status lists	From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) Programming Manual Manual System Software for S7-300/400 System and Standard Functions (http://support.automation.siemens.com/WW/view/en/1214574) STEP 7 online help
Commissioning an integrated PROFINET interface Commissioning PROFINET	Manual Automation System S7-300, Getting Started Collection (http://support.automation.siemens.com/WW/view/en/15390497) Operating instructions S7-300 CPU 31xC and CPU 31x: Installation (http://support.automation.siemens.com/WW/view/en/13008499)
CPU 319-3 PN/DP: Configuring the PROFINET interface CPU 317-2 PN/DP: Configuring the PROFINET X2 interface; configuring an ET 200S as a PROFINET IO device CP 443-1 Advanced (6GK7 443-1 EX40-0XE0) and CP 443-1 Advanced (6GK7443-1EX41-0XE0): Configuring the PROFINET interface with an IE/PB link and ET 200B	Getting Started Collection: PROFINET IO (http://support.automation.siemens.com/WW/view/en/19290251)
CP 443-1 (EX20)	S7 CPs for Industrial Ethernet, CP 443-1 (http://support.automation.siemens.com/WW/view/en/27013386)
Manual for CP 343-1 LEAN (CX10)	S7 CPs for Industrial Ethernet, CP 343-1 Lean (http://support.automation.siemens.com/WW/view/en/23643456) Equipment Manual
Manual for CP 343-1 (EX30)	S7 CPs for Industrial Ethernet, CP 343-1 (http://support.automation.siemens.com/WW/view/en/24485272) Equipment Manual
Manual for CP 343-1 Adv (GX21)	S7 CPs Advanced for Industrial Ethernet, CP 343-1 (http://support.automation.siemens.com/WW/view/en/22261695)

Information	Source
SNMP OPC server	Internet pages on SNMP OPC server (http://www.automation.siemens.com/net/html_76/produkte/040_snmp.htm)
SNMP	Internet pages on PROFIBUS & PROFINET International (http://www.profibus.com) and SMP (http://www.snmp.org)
SIMATIC iMap	Manual Commissioning SIMATIC iMap systems (http://support.automation.siemens.com/WW/view/en/22761971) Getting Started Getting Started with SIMATIC iMap (http://support.automation.siemens.com/WW/view/en/8776710)
Primary Setup Tool	Download (http://support.automation.siemens.com/WW/view/en/14929629)
Diagnostic data records	Programming Guide From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930)
Data security in automation	Operating instructions SCALANCE S and Softnet security client (http://support.automation.siemens.com/WW/view/en/21718449)
SIMATIC safety engineering	System Manual Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443)

Table A- 3   Applications associated with PROFINET

Information	Source
Questions on PN response times for typical configurations on PROFINET IO, especially: • How long does it take for a distributed output to respond to a distributed input? • What is the influence of IWLAN routes? • What influence does the communication via PROFINET IO have on the cycle time of the IO controller? • What update time will be required?	Establishing the PN response time for typical configurations on PROFINET IO (http://support.automation.siemens.com/WW/view/en/21869080)

A.2 RJ45 and M12 cable pin assignment

Introduction

The pin assignments described in the following paragraphs are written for RJ45 plugs and M12 plugs.

You only need consider this chapter if you are using fixed port settings.
(Refer also to chapter Settings for minimum startup times (Page 78)).

However, use the automatic port setting (transmission medium / duplex: "Automatic settings" in the "Options" strip in the port properties), can always be used as patch cables.

If you are using a fixed port setting, then you must connect two switch ports or two end device ports with a cross cable.

Pin assignment for the RJ45 plug connection of a cross cable.

Table A- 4   Pin assignment for the RJ45 plug connection of a cross cable

Plug on the PN device 1		Plug on the PN device 2	
Pin no.	Color of wire pairs with IE/PN	Pin no.	Color of wire pairs with IE/PN
1	Yellow	1	White
2	Orange	2	Blue
3	White	3	Yellow
6	Blue	6	Orange

Pin assignment for the RJ45 plug connection of a patch cable

Table A- 5   Pin assignment for the RJ45 plug connection of a patch cable

Plug on the PN device 1		Plug on the PN device 2	
Pin no.	Color of wire pairs with IE/PN	Pin no.	Color of wire pairs with IE/PN
1	Yellow	1	Yellow
2	Orange	2	Orange
3	White	3	White
6	Blue	6	Blue

Pin assignment for the M12 plug connection of a cross cable

Table A- 6   Pin assignment for the M12 plug connection of a cross cable

Plug on the PN device 1		Plug on the PN device 2	
Pin no.	Color of wire pairs with IE/PN	Pin no.	Color of wire pairs with IE/PN
1	White	1	Yellow
2	Yellow	2	White
3	Blue	3	Orange
4	Orange	4	Blue

Pin assignment for the M12 plug connection of a patch cable

Table A- 7   Pin assignment for the M12 plug connection of a patch cable

Plug on the PN device 1		Plug on the PN device 2	
Pin no.	Color of wire pairs with IE/PN	Pin no.	Color of wire pairs with IE/PN
1	White	1	White
2	Yellow	2	Yellow
3	Blue	3	Blue
4	Orange	4	Orange

Glossary

10 base T/F

Ethernet standard; supports transmission rates up to 10 Mbps.

100 base T/F

Ethernet standard; supports transmission rates up to 100 Mbps.

1000 base T/F

Ethernet standard; supports transmission rates up to 1000 Mbps.

Accumulator

Accumulators represent CPU register and are used as buffer memory for download, transfer, comparison, calculation and conversion operations.

See also CPU

API

The value of the API (Application Process Identifier) parameter specifies the application that is processing the IO data.

PROFINET standard IEC 61158 assigns profiles to certain APIs (PROFIdrive, PROFIslave) which are defined by the PROFINET User Organization.

The standard API is 0.

Application

→ *User program*

Application

An application is a program that runs directly on the MS-DOS / Windows operating system. Applications on the programming device are for example STEP 7.

Backplane bus

The backplane bus is a serial data bus. It supplies power to the modules and is also used by the modules to communicate with each other. Bus connectors interconnect the modules.

Bus

> A bus is a communication medium connecting several nodes. Data can be transferred via serial or parallel circuits, that is, via electrical conductors or fiber optic.

Bus segment

> A bus segment is a self-contained section of a serial bus system. Bus segments are interconnected by way of repeaters, for example, in PROFIBUS DP.

CAT 3

> Twisted-pair cable comes in different versions. Several versions are specified in the Ethernet standard.

> There are several categories, but only CAT 3 and CAT 5 are relevant to networks. The two types of cable differ in terms of their maximum permitted frequency and the attenuation values (weakening of signals across a specific distance).

> CAT 3 is a twisted-pair cable for 10 base T Ethernet.

> CAT 5 is a twisted-pair cable for 100 base T Fast Ethernet.

CAT 5

> → *CAT 3*

Category 3

> → *CAT 3*

Category 5

> → *CAT 3*

Central module

> → *CPU*

Changing IO devices during operation (partner ports)

> Functionality of a PROFINET device.

> If the IO controller and the IO device support this Function, then an IO device port "changing partner ports" from other devices can be assigned by means of configuration, so that at all times via this port at a specific time communication can take place with one of these changing IO devices. However, it is only the changing device that may be physically linked with the changing port that is currently being communicated with.

> All IO devices behind a changing port are initially disabled by default. In order to exchange user data with a changing device, after creating the physical connection between the changing port and the changing IO device, initially this must be activated using SFC 12.

Coaxial cable

A coaxial cable, also known as "coax", is a metal conductor system used in HF transmission circuits, for example, as radio and TV antenna cable, and in modern networks demanding high data transmission rates. The inner conductor of a coaxial cable is sheathed by a tube-like outer conductor. These conductors are separated by plastic insulation. In contrast to other cables, this type of cable provides a high degree of immunity to interference and EMC compatibility.

Code block

A SIMATIC S7 code block contains part of the **STEP 7** user program.
(in contrast to a DB: this contains only data.)

See also Data block

COM

Component **O**bject **M**odel. Microsoft specification for Windows objects based on OLE.

Automation systems are mapped onto objects in PROFINET CBA. An object consists of interfaces and properties. Two objects can communicate on the basis of these interfaces and properties.

Communication cycle and reserving the transmission bandwidth

PROFINET IO is a scalable real-time communication system based on the layer 2 protocol for Fast Ethernet. With the transmission procedure RT for time-critical process data and IRT for considerably precise as well as isochronous processes, this gives you two performance levels for real-time support.

Communication processor

Communication processors are modules used for point-to-point and bus topologies.

Component Based Automation

→ *PROFINET CBA*

Configuration

Assignment of modules to racks / slots and (for example with signal modules) addresses.

Consistent data

Data which belongs together in terms of content and must not be separated is known as consistent data.

For example, the values of analog modules must always be handled as a whole, that is, the value of an analog module must not be corrupted as a result of read access at two different points of time.

CP

→ *Communication processor*

CPU

Central processing unit = CPU of the S7 automation system with a control and arithmetic unit, memory, operating system, and interface for programming device.

Cycle time

The cycle time represents the time a CPU requires for one execution of the user program.

See also User program

Data block

Data blocks (DB) are data areas in the user program which contain user data. There are global data blocks which can be accessed by all code blocks, and instance data blocks which are assigned to a specific FB call.

DCOM

Distributed **COM**. Enhanced COM standard for remote object communication across device boundaries. DCOM is based on the RPC protocol, which in turn is based on TCP/IP. PROFINET CBA devices deploy the DCOM technology to exchange data which are not time-sensitive, such as process data, diagnostics data and parameter data.

PROFINET V1.0 or later supports DCOM technology.

Members of the Profinet User Organization (PNO) can request a portable DCOM protocol stack which is tailored to PROFINET applications. This prevents any dependency on Microsoft and (further) developments of this technology, while maintaining compatibility with Microsoft solutions.

DCP

DCP (Discovery and Basic Configuration Protocol). Allows for the assignment of device parameters (for example, IP address) with manufacturer-specific project/program tools.

Default router

The default router is used when data has to be forwarded via TCP/IP to a partner located outside the actual network.

In STEP 7, the default router is named *Router* in the "Properties" dialog box. The "Properties" dialog box is opened with the menu command **Properties Ethernet interface > Parameter > Gateway**. STEP 7 assigns the local IP address to the default router by default.

The router address that is set on the PROFINET interface of the IO controller is automatically transferred for the configured IO device.

Detecting the network topology

LLDP (Link Layer Discovery Protocol) is a protocol that is used to detect the closest neighbors. It enables a device to send information about itself and to save information received from neighboring devices in the LLDP MIB. This information can be looked up via the SNMP. This information allows a network management system to determine the network topology.

Determinism

Determinism means that a system responds in a predictable (deterministic) manner.

Device

In the PROFINET environment, "device" is the generic term for:

- Automation systems (PLC, PC, for example)
- Distributed I/O systems
- Field devices (for example, PLC, PC, hydraulic devices, pneumatic devices) and
- Active network components (e.g. switches, routers)
- Gateways to PROFIBUS, AS interface or other field bus systems

Device names

Before an IO device can be addressed by an IO controller, it must have a device name. In PROFINET, this method was selected because it is simpler to work with names than with complex IP addresses.

The assignment of a device name for a specific IO device can be compared to setting the PROFIBUS address of a DP slave.

When it ships, an IO device does not have a device name. An IO device can only be addressed by an IO controller, for example for the transfer of project engineering data (including the IP address) during startup or for user data exchange in cyclic operation, after it has been assigned a device name with the programming device/PC .

Note
Obtain device names with a different method

Some CPUs offer the possibility to "obtain device names with a different method". More information about his can be found in chapter: Auto-Hotspot

An exception to this is the PROFINET functionality "Device replacement without removable media / PD" In the case of IO devices for which "Device replacement without removable media / PD" has been configured, the device name of the IO controller is assigned on the basis of the topological configuration.

Alternatively, the device name can be written in the PD directly to the Micro Memory Card.

Device replacement without removable media / PD

IO devices having this function can be replaced simply:

- A removable medium (such as Micro Memory Card) with stored device name
  is not required.

- The device name does not have to be assigned with the PD.

The replaced IO device obtains the device name from the IO controller, not from the removable medium or from the programming device. For this purpose, the IO controller uses the configured topology and the neighbor relationships determined by the IO devices. The configured set topology must agree with the actual topology.

Diagnostic interrupt

Modules capable of diagnostics operations report detected system errors to the CPU by means of diagnostic interrupts.

See also CPU

Diagnostics

→ *System diagnostics*

Diagnostics buffer

The diagnostics buffer represents a buffered memory area in the CPU. It stores diagnostic events in the order of their occurrence.

DP master

A master which behaves in accordance with EN 50170, Part 3 is known as a DP master.

See also Master

DP slave

A slave operated on PROFIBUS with PROFIBUS DP protocol and in accordance with EN 50170, Part 3 is referred to as DP slave.

See also Slave

DPV1

The designation DPV1 means extension of the functionality of the acyclical services (to include new interrupts, for example) provided by the DP protocol. The DPV1 functionality has been incorporated into IEC 61158/EN 50170, volume 2, PROFIBUS.

Error handling via OB

After the operating system has detected a specific error (e.g. access error with **STEP 7 user program**), it calls a dedicated organization block (error OB) that determines further CPU actions.

ERTEC

ERTEC - Enhanced Real Time Ethernet Controller

The new ERTEC200 and ERTEC400 ASICs are designed for automation applications. They support the PROFINET protocol and are required for IRT operation. ASIC is the acronym for Application Specific Integrated Circuits. PROFINET ASICs are components which provide a wide range of functions for developing user-specific devices. They convert the requirements of the PROFINET standard into high-performance, high-density circuits.

Benefits of ERTEC:

- Easy integration of switch functionality in devices
- Easy and cost-effective setup of linear bus topology
- Minimized communication load on devices

FB

→ *Function block*

FC

→ *Function*

Function

According to IEC 1131-3, a function (FC) is a code block without static data. A function allows parameters to be passed in the user program. Functions are therefore suitable for programming frequently occurring complex functions, e.g. calculations.

Function block

According to IEC 1131-3, a function block (FB) is a code block with static data. A function block allows parameters to be transferred to the user program. Function blocks are therefore suitable for programming frequently recurring, complex functions, e.g., rules, mode selection.

GSD file

The properties of a PROFINET device are described in a GSD file
(General Station Description) that contains all the information required for configuration.

As with PROFIBUS, you can link a PROFINET device in STEP 7 by means of a GSD file.

In PROFINET IO, the GSD file is in XML format. The structure of the GSD file conforms to ISO 15734, which is the world-wide standard for device descriptions.

In PROFIBUS, the GSD file is in ASCII format.

I-device

The "I-device" functionality (intelligent IO device) of a CPU allows data to be exchanged with an IO controller and therefore to use the CPU, for example, as an intelligent preprocessing unit of subprocesses. The I-device is linked as an IO device to a "higher-level" IO controller.

Industrial Ethernet

Industrial Ethernet is a directive for connecting to an Ethernet in an industrial environment. The greatest difference to standard Ethernet is in the mechanical capacity and the immunity to interference for the individual components.

Industrial Wireless LAN

In addition to data communication to IEEE 802.11, SIMATIC NET Industrial Wireless LAN provides a number of extremely useful enhancements (ifeatures) for the industrial customer. IWLAN is particularly suited for complex industrial applications with requirement for reliable radio communication, owing to the following properties:

- Automatic roaming when the connection to Industrial Ethernet is interrupted (Forced Roaming)

- Cost savings generated by using a single wireless network for secure operation of a process with both process-critical data (alarm message, for example) and non-critical communication (service and diagnostics, for example)

- Cost-effective connection to devices in remote environments that are difficult to access

- Predictable data traffic (deterministic) and defined response times

- For use in hazardous areas of Zone 2

- Cyclical monitoring of the wireless link (link check)

Interface, MPI-compatible

→ *MPI*

Interrupt

The CPU's operating system distinguishes between different priority classes for user program execution. These priority classes include interrupts, e.g. process interrupts. When an interrupt is triggered, the operating system automatically calls an assigned OB. In this OB the user can program the desired response (e.g. in an FB).

See also Operating system

Interrupt, diagnostic

→ *Diagnostic interrupt*

Interrupt, process

→ *Process interrupt*

IP address

To allow a PROFINET device to be addressed as a node on Industrial Ethernet, this device also requires an IP address that is unique on that network. The IP address is made up of 4 decimal numbers with a range of values from 0 through 255. The decimal numbers are separated by periods.

The IP address is made up of the following:

- Address of the network and
- Address of the node (generally called the host or network node).

IRT

Synchronized transmission procedure for the cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth within the send clock is available for the IRT IO data. The reserved bandwidth ensures that the IRT data can be transmitted at reserved, synchronized intervals whilst remaining uninfluenced even by other greater network loads (e.g. TCP / IP communication or additional real time communication).

Isochronous mode

In order to maximize deterministic performance, the process data, the transmission cycle via PROFIBUS DP or PROFINET IO, as well as the user program are synchronized. The input and output data of distributed I/O devices in the system are detected and output simultaneously. The constant PROFIBUS DP cycle / PROFINET IO cycle is the clock generator.

LAN

Local Area Network; interconnects multiple computers within a company. The geographical topology of a LAN is limited to the local premises and is only available to the operating company or institution.

Line depth

Describes the number of interconnected external switches or integrated switches in the line.

MAC address

Every PROFINET device is assigned a worldwide unique device identifier at the factory. This 6-byte long device identifier is the MAC address.

The MAC address consists of:

- 3-byte vendor identifier and

- 3-byte device identifier (consecutive number).

The MAC address is normally printed on the front of the device: e.g. 08-00-06-6B-80-C0.

Maintenance demanded

Continuity and reliability of a PROFINET device depends on the early recognition and elimination of potential faults in order to prevent any loss of production.

This requires the definition of different maintenance information relating to the maintenance demanded status.

A "maintenance demanded" system alarm can be defined for various wear-and-tear parameters. For example, the alarm may recommend inspection of a component which has reached a specific number of operating hours.

A "maintenance demanded" alarm is generated if a component must be replaced within a conceivable period.

(Example printer: A maintenance required alarm is generated to indicate that the toner / printer cartridge requires immediate replacement.)

Maintenance required

Continuity and reliability of a PROFINET device depends on the early recognition and elimination of potential faults in order to prevent any loss of production.

This requires the definition of different maintenance information relating to maintenance required.

A "maintenance required" system alarm can be defined for various wear-and-tear parameters. For example, the alarm may recommend inspection of a component which has reached a specific number of operating hours.

A "maintenance required" alarm is generated if a component must be replaced within a short period.

(Example printer: A maintenance demanded alarm is generated to indicate that the toner / printer cartridge will have to be replaced in a few days.)

Master

When a master has the token, it can send data to other nodes and request data from other nodes (= active node).

Media redundancy

Through the so-called Media Redundancy Protocol (MRP) it is possible to setup possible redundant networks. Redundant transmission links (ring topology) ensure that an alternative communication path is made available if a transmission link fails. The PROFINET devices that are a part of this redundant network form an MRP domain.

MIB

An MIB (Management Information Base) is a data base of a device. SNMP clients access this data base in the device. The S7 device family supports, among others, the following standard MIBs:

- MIB II, standardized in the RFC 1213

- LLDP MIB, standardized in the international standard IEE 802.1AB

- LLDP PNIO-MIB, standardized in the international standard IEE 61158-6-10

Micro Memory Card (MMC)

Micro Memory Cards are memory media for CPUs and CPs. When compared with a memory card, a Micro Memory Card is smaller.

See also Memory Card

MPI

The multipoint interface (MPI) represents the programming device interface of SIMATIC S7. It enables multiple nodes (PGs, text-based displays, OPs) to be operated simultaneously by one or more CPUs. Each node is identified by its unique (MPI) address.

MPI address

→ *MPI*

NCM PC

→ *SIMATIC NCM PC*

Network

A network consists of one or more interconnected subnets with any number of nodes. Several networks can exist alongside each other.

NTP

The Network Time Protocol (NTP) is a standard for synchronizing clocks in automation systems via Industrial Ethernet. NTP uses the UDP wireless network protocol.

OB

→ *Organization blocks*

OLE

Object Linking and Embedding is a central architectural principle in Windows. OLE is a Microsoft technology which enables object linking and data exchange between programs.

OPC

OLE for Process Control is an industrial standard which defines vendor-independent access to industrial communication networks on the basis of OLE.

OPC (OLE for Process Control) defines a standard communication interface for automation technology. OPC enables access to OLE (Object Linking and Embedding). OLE is a component model of Microsoft. Components are software objects or applications which make their functionality available to other applications.

Communication via the OPC interface is based on COM/DCOM. In this case, the object is the process image.

The OPC interface was designed as an industrial standard by leading companies in the automation industry with support from Microsoft Corporation. Applications accessing process data were previously restricted to the access mechanisms of the communications network of a single vendor. The standardized OPC interface harmonizes access to the communication networks of any vendor.

OPC client

An OPC client is a user program which accesses process data using the OPC interface. OPC server provides access to process data.

OPC server

The OPC server provides a wide range of functions to an OPC client for communication over industrial networks.

For additional information, refer to the *Industrial Communication with PG/PC* manual.

Operating state

SIMATIC S7 automation systems know the following operating states: STOP, START, RUN.

See also START, RUN

Operating system

The CPU operating system organizes all the CPU functions and processes which are not associated with a specific control task.

Option handling

Option handling enables you to set up your automation system for future expansions or options. Option handling means that you configure the planned maximum configuration of your automation system in advance and can vary later depending on the user program. Option handling exists with and without RESERVE modules.

Organization blocks

Organization blocks (OBs) form the interface between the CPU operating system and the user program. The order in which the user program is executed is defined in the organization blocks.

Parameters

1. Variable of a **STEP 7** code block

2. Variables used to set the behavior of a module (one or more per module).

As delivered, each module has an appropriate default setting that can be changed via configuration in **STEP 7**.

The parameters are divided into static and dynamic parameters

Parameters, static

Unlike dynamic parameters, static parameters of modules cannot be changed by the user program. You can only modify these parameters by editing your configuration in **STEP 7**, for example, modification of the input delay parameters of a digital signal input module.

PC station

→ *SIMATIC PC station*

PCD

The PROFINET component description is the description of the components you have generated in your engineering system (for example, STEP 7). The PCD is an XML file that you can import into SIMATIC iMap so that you can configure the PROFINET CBA communication.

PG

→ *Programming device*

PLC

→ *Programmable logic controller*

PLC

A PLC in the context of SIMATIC S7 --> is a programmable logic controller.

See also Programmable Logic Controller

PNO

Technical committee that defines and further develops the PROFIBUS and PROFINET standards with the following homepage: http://www.profinet.com.

Prioritized startup

Prioritized startup describes the PROFINET functionality to accelerate the startup of IO devices for RT and IRT communication within a PROFINET IO system. The function reduces the time that the correspondingly configured IO devices require in order to return to the cyclic user data exchange in the following cases:

- After the supply voltage has returned

- After a station has returned

- After IO devices have been activated

Process image

The process image is part of CPU system memory. At the start of cyclic program execution, the signal states at the input modules are written to the process image of the inputs. At the end of cyclic program execution, the signal status of the process image of the outputs is transferred to the output modules.

See also System memory

Process interrupt

A process interrupt is triggered by interrupt-triggering modules as a result of a specific event in the process. The process interrupt is reported to the CPU. The assigned organization block will be processed according to interrupt priority.

See also Organization Block

Product version

The product version identifies differences between products which have the same order number. The product version is incremented when forward-compatible functions are enhanced, after production-related modifications (use of new parts/components) and for bug fixes.

PROFIBUS

Process Field Bus - European field bus standard.

PROFIBUS device

A PROFIBUS device has at least one PROFIBUS interface with an electrical (RS485) or optical (polymer optical fiber, POF) interface.

PROFIBUS DP

A PROFIBUS with the DP protocol that complies with EN 50170. DP stands for distributed peripheral (IO) = fast, real-time, cyclic data exchange. From the perspective of the user program, the distributed IOs are addressed in exactly the same way as the central IOs.

PROFIenergy

Function for energy saving in the process, for example, during breaks through short-term switch off of the entire system through standardized PROFIenergy-commands.

PROFINET

Within the framework of Totally Integrated Automation (TIA), PROFINET IO is the consistent further development of:

- PROFIBUS DP, the established fieldbus and

- Industrial Ethernet

PROFINET IO is based on 20 years of experience with the successful PROFIBUS DP and combines the normal user operations with the simultaneous use of innovative concepts of the Ethernet technology. This ensures the smooth migration of PROFIBUS DP into the PROFINET world.

PROFINET IO as the Ethernet-based automation standard of PROFIBUS International defines a cross-vendor communication, automation, and engineering model.

With PROFINET IO a switching technology is implemented that allows all stations to access the network at any time. In this way, the network can be used much more efficiently through the simultaneous data transfer of several nodes. Simultaneous sending and receiving is enabled through the full-duplex operation of Switched Ethernet.

PROFINET IO is based on Switched Ethernet full-duplex operation and a bandwidth of 100 Mbps.

PROFINET CBA

As part of PROFINET, PROFINET CBA (Component Based Automation) is an automation concept that focuses on the following:

- Implementation of modular applications

- Machine - machine communication

PROFINET CBA lets you create distributed automation solutions based on off-the-shelf components and partial solutions. This concept satisfies demands for a higher degree of modularity in the field of mechanical and systems engineering by extensive distribution of intelligent processes.

With Component Based Automation you can implement complete technological modules as standardized components that can be used in large systems.

You create the modular, intelligent components of the PROFINET CBA in an engineering tool, which may differ according to the device manufacturer. Components that are formed from SIMATIC devices are created with STEP 7, and are interconnected using the SIMATIC iMAP tool.

PROFINET component

A PROFINET component incorporates all the hardware configuration data, the module parameters and the associated user program for use in PROFINET CBA.
The PROFINET component is made up as follows:

- Technological function

  The (optional) technological (software) function includes the interface to other PROFINET components in the form of interconnectable inputs and outputs.

- Device

  The device is the representation of the physical programmable controller or field device, including any I/O, sensors and actuators, the mechanical system and the device's firmware.

PROFINET Component Description

→ PCD

PROFINET device

A PROFINET device always has a PROFINET interface (electrical, optical, wireless). A lot of devices also have a PROFIBUS DP interface to connect PROFIBUS devices.

PROFINET IO controller

Device used to address the connected IO devices. This means that the IO controller exchanges input and output signals with assigned field devices. The IO controller is often the controller on which the automation program runs.

PROFINET IO device

A decentralized field device that is assigned to one of the IO controllers
(e.g. remote IO, valve terminals, frequency converters, switches)

PROFINET IO Supervisor

Programming device, PC or HMI device used for commissioning and diagnostics.

PROFINET IO system

PROFINET IO controller with assigned PROFINET IO devices.

PROFINET IO

As part of PROFINET, PROFINET IO is a communication concept that is used to implement modular, distributed applications.

PROFINET IO allows you to create automation solutions of the type with which you are familiar from PROFIBUS DP.

PROFINET IO is implemented using the PROFINET standard for programmable controllers (IEC 61158-x-10).

The STEP 7 engineering tool helps you to structure and configure an automation solution.

In STEP 7 you have the same application view, regardless of whether you are configuring PROFINET devices or PROFIBUS devices. The user program for PROFINET IO and PROFIBUS DP looks the same. The same system function components and system state lists are used (were expanded for PN IO).

Programmable logic controller

Programmable controllers (PLCs) are electronic controllers whose function is stored as a program in the control unit. The structure and wiring of the device does not therefore depend on the controller's function. A programmable logic controller is structured like a computer. It consists of a CPU with memory, input/output modules and an internal bus system. The IOs and the programming language are oriented to control engineering needs.

Programming device

Programming devices are essentially compact and portable PCs which are suitable for industrial applications. They are identified by a special hardware and software for programmable logic controllers.

Proxy

The PROFINET device with proxy functionality is the substitute for a PROFIBUS device on Ethernet. The proxy functionality allows a PROFIBUS device to communicate not only with its master but also with all nodes on PROFINET.

With PROFINET, existing PROFIBUS systems can be integrated into the PROFINET communication with the aid of an IE/PB link, for example. The IE/PB link then handles communication via PROFINET on behalf of the PROFIBUS components.

In this way, you can link both DPV0 and DPV1 slaves to PROFINET.

Proxy functionality

→ *Proxy*

RAM

RAM (Random Access Memory) is a semiconductor read/write memory.

Real time and determinisms

Real-time means that a system processes external events within a defined time.

Determinism means that a system responds in a predictable (deterministic) manner.

Real-time communication

Collective term for RT and IRT.

PROFINET uses its own real-time channel (RT), reserved transmission bandwidth (IRT) instead of TCP/IP to communicate time-sensitive IO user data.

Restart

On CPU start-up (e.g. after is switched from STOP to RUN mode via selector switch or with POWER ON), OB100 (restart) is initially executed, prior to cyclic program execution (OB1). On restart, the input process image is read in and the **STEP 7** user program is executed, starting at the first instruction in OB1.

Retentive memory

A memory area is considered retentive if its contents are retained even after a power loss and transitions from STOP to RUN. The non-retentive area of memory flag bits, timers and counters is reset following a power failure and a transition from the STOP mode to the RUN mode.

Retentive can be the:

- Bit memory
- S7 timers
- S7 counters
- Data areas

Router

A router interconnects two subnets. A router works in a similar way to a switch. With a router, however, you can also specify which communication nodes may communicate via the router and which may not. The communication nodes on various sides of a router can only communicate with one another if you have explicitly enabled communication between these nodes via the router. Real-time data cannot be exchanged beyond subnet boundaries.

RT

Real-time means that a system processes external events within a defined time.

Security

Generic term for all the measures taken to protect against

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability due to the destruction of data

Segment

→ *Bus segment*

SELV/PELV

The term denotes circuits with safety extra-low voltage. Siemens SITOP power supplies provide this protection, for example. For additional information, refer to the EN 60950-1 (2001) standard.

Send clock

Period between two successive intervals for IRT or RT communication.
The send clock is the shortest possible transmit interval for exchanging data.

For IRT with the "high performance" option, in addition to the "even" transmission tact (250 µs, 500 µs, 1 ms, 2 ms, 4 ms), the send clock can be set as "odd" between 250 µs and 4 ms at any multiple of 125 µs: 375 µs, 625 µs … 3.875 ms.

With "odd" send frequencies, the following applies for all PROFINET IO-devices:

- Update time = send frequency

- no amendment of IRT with the "high performance" option possible through RT devices

SFB

→ *System function block*

SFC

→ *System function*

Shared Device

The "shared device" function allows the submodules of an IO device to be divided up among different IO controllers.

Signal module

Signal modules (SM) form the interface between the process and the PLC. There are digital input and output modules (input/output module, digital) and analog input and output modules. (Input/output module, analog)

SIMATIC

The term denotes Siemens AG products and systems for industrial automation.

SIMATIC NCM PC

SIMATIC NCM PC is a version of STEP 7 tailored for PC configuration. It offers the full range of STEP 7 functions for PC stations.

SIMATIC NCM PC is the central tool for configuring the communication services for your PC station. The configuration data generated with this tool must be downloaded to the PC station or exported. This makes the PC station ready for communication.

SIMATIC NET

Siemens Industrial Communication division for Networks and Network Components.

SIMATIC PC station

A "PC station" is a PC with communication modules and software components within a SIMATIC automation solution.

SIMATIC iMap

Engineering tool for configuration, commissioning, and monitoring of modular distributed automation systems. It is based on the PROFINET standard.

SINEMA E

SINEMA E (SIMATIC Network Manager Engineering) is planning, simulation and configuration software that simplifies the task of installing and starting up a WLAN network with the help of simulation functions.

- Planning a WLAN infrastructure

  By modeling the environment - external area, internal area etc., you can calculate the distribution of the electromagnetic fields. One the basis of this calculation you then position the access points and align their antennas.

- Simulating a WLAN infrastructure

  Simulating the planned wireless LAN allows you to calculate the position, range and attenuation without having to construct the LAN first. Simulation allows you to work out the optimum sending and receiving conditions when setting up a WLAN structure.

- Configuring a WLAN infrastructure

  You configure the WLAN devices offline and save all the relevant data (parameters, security settings) in a project. When online, all the WLAN devices are automatically conveyed via the LAN and the configured parameters are downloaded to the WLAN devices.

- Measurements for optimizing and maintaining a WLAN infrastructure

  You can support measurements and analyses at the start of planning with the optimal illumination of an available WLAN network. In addition, the measurements give important information in troubleshooting and maintenance.

- Report function

  Alongside the documentation of the measurement results, use the extensive report function for drawing up offers (Sales Wizard), for installation (device installation instructions), for acceptance, troubleshooting and expanding the WLAN network.

Slave

A slave can only exchange data after being requested to do so by the master.

SNMP

SNMP (Simple Network Management Protocol) makes use of the connectionless UDP transport protocol. It consists of two network components, similar to the client/server model. The SNMP manager monitors the network nodes and the SNMP agents collect the various network-specific information in the individual network nodes and stores it in a structured form in the **MIB** (Management Information Base). This information allows a network management system to run detailed network diagnostics. Access to SNMP data from PROFINET devices is generally read only, except for a small amount of data that is not production-relevant.

STEP 7

STEP 7 is an engineering system and contains programming software for the creation of user programs for SIMATIC S7 controllers.

Subnet

All the devices connected by switches are located in the same network - a subnet. All the devices in a subnet can communicate directly with each other.

All devices in the same subnet have the same subnet mask.

A subnet is physically restricted by a router.

Subnet mask

The bits set in the subnet mask decide the part of the IP address that contains the address of the network.

In general the following applies:

- The network address is obtained from the IP address AND the subnet mask.

- The node address is obtained by an AND NOT operation on the IP address and subnet mask.

Substitute value

Substitute values are configurable values which output modules transfer to the process when the CPU switches to STOP mode.

In the event of an I/O access error, a substitute value can be written to the accumulator instead of the input value which could not be read (SFC 44).

Switch

Network components used to connect several computers or network segments in a local network (LAN).

Sync domain

All PROFINET devices that are to be synchronized via PROFINET IO with IRT must belong to a sync domain.

The sync domain consists of precisely one sync master and at least one sync slave.
The role of the sync master is normally done by an IO controller or switch.

Non-synchronized PROFINET devices are not a part of a sync domain.

System diagnostics

System diagnostics refers to the detection, evaluation, and signaling of errors that occur within the PLC, for example programming errors or module failures. System errors can be indicated by LEDs or in **STEP 7**.

System function

A system function (SFC) is a function that is integrated in the operating system of the CPU and can be called in the STEP 7 user program, when necessary.

System function block

A system function block (SFB) is a function block integrated in the CPU operating system that can be called in the STEP 7 user program when required.

System memory

System memory is an integrated RAM memory in the CPU. System memory contains the address areas (e.g. timers, counters, flag bits) and data areas that are required internally by the operating system (for example, communication buffers).

System status list

The system status list contains data that describes the current status of a SIMATIC S7. You can always use this list to obtain an overview of the following points:

- Status of the SIMATIC S7 extension.
- The current CPU configuration and configurable signal modules.
- The current states and processes in the CPU and in configurable signal modules.

TCP/IP

The Ethernet system is designed solely to carry data. It is comparable to a highway as a system for transporting goods and passengers. The data is actually transported by protocols. This is comparable to cars and commercial vehicles transporting passengers and goods on the highway.

Tasks handled by the basic Transmission Control Protocol (TCP) and Internet Protocol (IP) (abbreviated to TCP/IP):

1. The sender splits the data into a sequence of packets.

2. The packets are transported over the Ethernet to the correct recipient.

3. The recipient reassembles the data packets in the correct order.

4. Faulty packets are sent again until the recipient acknowledges that they have been transferred successfully.

Most higher-level protocols use TCP/IP to handle their tasks. The Hyper Text Transfer Protocol (HTTP), for example, transfers documents on the World Wide Web (WWW) which are written in Hyper Text Markup Language (HTML). Without this technology, you would not be able to view Web sites on your Internet browser.

Technological function

→ *PROFINET component*

Terminating resistor

The terminating resistor is used to avoid reflections on data links.

Token

Allows access to the bus for a limited time.

Topology

Network structure. Commonly used structures:

- Linear bus topology
- Ring topology
- Star topology
- Tree topology

Topology configuration

All the interconnected ports of the PROFINET devices in STEP 7 projects and their relationships to each other.

Transmission rate

Data transfer rate (in bps)

Twisted-pair

Fast Ethernet via twisted-pair cables is based on the IEEE 802.3u standard (100 Base-TX). The transmission medium is a shielded 2x2 twisted-pair cable with an impedance of 100 Ohm (AWG 22). The transmission characteristics of this cable must meet the requirements of category 5.

The maximum length of the connection between the terminal and the network component must not exceed 100 m. The connections are implemented according to the 100 Base-TX standard with the RJ-45 connector system.

UDT

User Defined Type: User-defined data type with any design.

Update time

Within this time interval an IO device / IO controller in the PROFINET IO system is supplied with new data by the IO controller / IO device. The send cycle can be configured separately for each IO device and determines the interval at which data are sent from the IO controller to the IO device (outputs) as well as data from the IO device to the IO controller (inputs).

Note

According to the Nyquist-Shannon sampling theorem, there is a changed value of a sensor after at latest an update cycle being executed twice in the IO controller. Further time delays can occur through back wall bus durations and analog digital conversion times in the IO device. After this time, the changed value can be accessed directly from the user program (for example, L PEW 267). If the value is accessed through the process image, the cycle time of the OB1 must be added twice.

User program

In SIMATIC, we distinguish between the operating systems of the CPU and user programs. The user program contains all instructions, declarations and data for signal processing through which a system or process can be controlled. It is assigned to a programmable module (for example CPU, FM) and can be structured in smaller units (blocks).

WAN

A network beyond LAN boundaries which allows, for example, intercontinental communication. Legal rights do not belong to the user but to the provider of the communication network.

Work memory

The working memory is integrated in the CPU and cannot be extended. It is used to run the code and process user program data. Programs only run in the working memory and system memory.

See also CPU

XML

XML (Extensible Markup Language) is a flexible, easy to understand data description language which can be learned easily. Information is exchanged with the aid of readable XML documents. These documents contain continuous text supplemented with structure data.

Index

A

Address assignment, 219
Application example, 257
Automation concept, 29
Available nodes, 229

B

Basic knowledge required, 3

C

Cause of the error, 235
Changing IO devices during operation
    Applicative conditions, 80
    Area of application, 81
    Use - configuring in HW Config, 82
Changing partner ports during operation, 80
Channel error, 236
Commissioning phase, 227
Communication
    IO controller, 181
    PROFINET, 58
Communication processor, 231
    Diagnostics, 231
Communication traffic, 40
Component, 259
Component Based Automation, 17, 29
Conditions
    for I-device, 129
Configure I-device, 105
    Application transfer area, 108
    as a shared device, 120
    Basic procedure, 103
    Generating a GSD File, 112
    higher-level system, 114
    IO transfer area, 110
    Lower-level IO system, 118
    Use, 113
Configuring, 180
    Isochronous mode, 145
    Shared Device, 88, 91
Connection, 27
    AS-Interface with PROFINET, 28

    PROFIBUS DP and PROFINET IO via IWLAN, 27
constant PROFINET IO:, 135
CP 343-1, 32
CP 443-1 Advanced, 32
CPU communication, 181
Cut through, 66

D

Data access, 63
Data exchange
    higher- and lower-level IO-system, 101
Default router, 218
Device, 247
Device identifier, 216
Device name, 215
    Assigning, 219
    structured, 215
Device number, 215
Device replacement without removable media / PD, 73
    Advantages, 74
    Definition, 73
    Requirement, 73
Diagnostic data record, 235, 236
Diagnostic status, 234
Diagnostics
    Access, 227
    Diagnostic status, 234
    I-device, 120
    Isochronous mode, 153
    Level, 226
    SIMATIC iMap, 249
    STEP 7, 228, 233
    User program, 233
Diagnostics view, 230
Disposal, 4
DNS conventions, 215
DP master, 19
    Class 2, 19
DP master system, 19
DP slave, 19