PROFINET basic principles

User manual

PHŒNIX CONTACT
INSPIRING INNOVATIONS

User manual
PROFINET basic principles

2017-04-05

Designation: UM EN PROFINET SYS

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This user manual is valid for:

PROFINET devices from Phoenix Contact

Please observe the following notes

User group of this manual

The use of products described in this manual is oriented exclusively to qualified electricians or persons instructed by them, who are familiar with applicable standards and other regulations regarding electrical engineering and, in particular, the relevant safety concepts.

Explanation of symbols used and signal words

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety measures that follow this symbol to avoid possible injury or death.

There are three different categories of personal injury that are indicated with a signal word.

DANGER This indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING This indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION This indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

This symbol together with the signal word **NOTE** and the accompanying text alert the reader to a situation which may cause damage or malfunction to the device, hardware/software, or surrounding property.

This symbol and the accompanying text provide the reader with additional information or refer to detailed sources of information.

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PHOENIX CONTACT GmbH & Co. KG
Flachsmarktstraße 8
32825 Blomberg
GERMANY

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Table of contents

1 PROFINET

1.1 PROFINET documentation

The PROFINET documentation from Phoenix Contact has a modular structure.

1.2 Target group of this user manual

This user manual is directed at those responsible for programming user programs, or configuring, starting up, and servicing automation systems.

1.3 Basic knowledge required

The following knowledge is required to understand the user manual:
- General knowledge with regard to automation technology
- Knowledge on how to use computers or equipment similar to a PC (e.g., programming devices) under the Windows® operating system
- Knowledge of how to use PC Worx
- Knowledge of how to use PROFINET

Available PROFINET documents

"PROFINET basic principles" user manual
UM EN PROFINET SYS

This user manual describes PROFINET system basics.
These include:
- PROFINET development
- PROFINET versions
- PROFINET properties
- PROFINET installation
- PROFINET startup

Quick start guides

- "Installing and starting up the AXC 1050 PN STARTERKIT" quick start guide
  UM QS EN AXC 1050 PN STARTERKIT
- "Configuring INTERBUS devices in a PROFINET IO network using the example of STEP 7" quick start guide
  UM QS EN PROFINET PROXY IB

User manual

- "PROFINET controller/device functions"
  UM EN PROFINET CTRL DEV

Device-specific data sheets

The data sheets describe the specific properties of PROFINET devices.
These include:

- Function description
- Ordering data and technical data
- Local diagnostics and status indicators
- Pin assignment and connection example
- Programming data and configuration data

Make sure you always use the latest documentation.
It can be downloaded at phoenixcontact.net/products.

PROFINET documentation

German documents

- PROFINET Planungsrichtlinie,
  Version 1.14, Dezember 2014, Bestellnummer: 8.061
  „PROFINET_Planung_8061_V114_Dez14.pdf“
- PROFINET Montagerichtlinie,
  Version 1.0, Januar 2009, Bestellnummer: 8.071
  „PROFINET_Montagerichtlinie_8071_V10__Jan09.pdf
- PROFINET Inbetriebnahmerichtlinie,
  Version 1.36, Dezember 2014, Bestellnummer: 8.081
  „PROFINET_Inbetriebnahme_8081_V136_Dec14.pdf“

English documents

- PROFINET Design Guideline,
  Version 1.14, December 2014, Order No.: 8.062
  “PROFINET_Design_8062_V114_Dec14.pdf”
- PROFINET Installation Guideline for Cabling and Assembly,
  Version 1.0, January 2009, Order No.: 8.072
  “PROFINET_Guideline_Assembly_8072_V10_Jan09.pdf”
- PROFINET Commissioning Guideline,
  Version 1.36, December 2014, Order No.: 8.082
  “PROFINET_Commissioning_8082_V136_Dec14.pdf”

Make sure you always use the latest documentation.
It can be downloaded at http://www.profibus.com/download/installation-guide/.

1.4 PROFINET in automation

The cry for increased productivity of machines and systems while simultaneously cutting costs has always been the driving force behind innovations in industrial automation. Machine builders and manufacturing companies can hold their ground in international markets all the better if their solutions are more competitive.

Continuous optimization of the production process is therefore vital. Productivity can be increased with the help of a better information flow in order to make better decisions. On the other hand, the integration of machines and components in the respective network must be simplified to cut engineering and startup times.

Company networks are at present characterized by complex couplings and data exchange mechanisms between the many island solutions in the production area and between the factory and command level. Transparent access to machine data as would be necessary for perfect job and production control is not possible without a great deal of effort. The aim must therefore be to develop a uniform network structure that will guarantee that all machine and plant parts are networked and connected to the production planning and company command level. The key to implementing this demand is Ethernet, as the transfer medium is established in office communications and is already used in industrial environments to link distributed machine and system components with one another as well as with higher-level systems.

PROFINET has clearly distinguished itself as the open Industrial Ethernet standard. PROFINET is a network protocol based on standard Ethernet, into which proven Ethernet technologies can be integrated.

Since Ethernet is widespread in office levels, data can be exchanged between the office and production levels or even worldwide by means of the Internet. It is a means of remote control and monitoring, making remote servicing and maintenance possible.

PROFINET is the logical continuation of

- PROFIBUS DP and
- Industrial Ethernet

Experience gained from both systems has been integrated into PROFINET.

PROFINET

- Automation in real time
- Uses TCP/IP and IT standards
- Enables seamless integration of fieldbuses
- Improves vertical integration

1.5 Potential applications of PROFINET

Applications

There are a wide range of possible applications for PROFINET. In addition to automotive construction, there are also reference applications in water/wastewater processing, shipbuilding, logistics, process technology, machine building, and in building automation.

Figure 1-1 PROFINET applications

Investment protection

The substantial investments made to date in automation products and solutions by manufacturers and users are protected, as a smooth transition from fieldbus to Ethernet must be achieved. Older systems or sub-segments, in which Ethernet communication is not advantageous, can be integrated into the PROFINET network without any loss of information. For the user, this means investment protection for existing systems; furthermore, a gradual introduction is possible to the PROFINET system.

1.6 PROFIBUS-Nutzerorganisation as technology promoters

PNO

The PROFIBUS-Nutzerorganisation e. V. (PROFIBUS User Organization or PNO) is a technical committee, which defines and further develops the PROFIBUS and PROFINET standard.

More than 300 manufacturers and users have founded the standardized communication technologies PROFIBUS and PROFINET in the PNO, to jointly promote the technical further development as well as the international implementation of technologies. The PROFIBUS-Nutzerorganisation is a registered association. Membership is available for all companies and research facilities, both in Germany and abroad. Each component manufacturer can receive the protocol specification via the PNO.

IEC 61158

Since the publication of this standard, the various working circles within the PNO have managed to introduce the most important requirements into the international standard IEC 61158. PROFINET technology is very much embedded in the established non-proprietary specification processes of the PROFIBUS-Nutzerorganisation (PNO).

Certification

The PNO draws up and updates open specifications for actual communication, installation guidelines, and connector definitions, as well as certification procedures and user profiles. For PROFINET, certification is obligatory and guaranteed through the interoperability of PROFINET devices. The PROFINET devices are checked according to specific tests and allocated to various conformance classes in test and certification classes. The PNO centrally monitors accreditation of testing laboratories.

1.7 Phoenix Contact as experts

To simplify access to this technology for PROFINET users, **Phoenix Contact**, **Phoenix Testlab**, and **Phoenix Contact Software** have combined their expertise in the PHOENIX CONTACT COMPETENCE CENTER (PCCC). The PHOENIX CONTACT COMPETENCE CENTER is accredited by the PROFIBUS-Nutzerorganisation.

The collaboration of the three companies enables services throughout the entire life cycle of a PROFINET solution.

Concept and technical specification

During the development phase, the experts from the internal accredited PROFINET test laboratory at the Phoenix Testlab advise on and certify the areas of EMC, wireless, environmental simulation, and electrical device safety. In doing so, all applicable standards are recorded and the resulting product requirements are documented.

Development

The PROFINET business segment at Phoenix Contact Software supports device manufacturers and solution providers during the development phase with a specific portfolio of products and services. Suitable technology components are available for integration into the customer's target platform for the different PROFINET device types (PROFINET controller, PROFINET devices). This integration or porting is carried out based on your requirements.

Conformance testing

Phoenix Testlab GmbH was certified in October 2007 as a test laboratory for performing conformity tests for Phoenix Contact devices. Phoenix Testlab carries out certification testing for series end products as well as accompanying development tests. The advantage of the latter is that any problems with the device, which could endanger a positive overall test, are detected at an early stage and can be corrected during the development phase. The device developer decides which functions are to be tested and at what point.

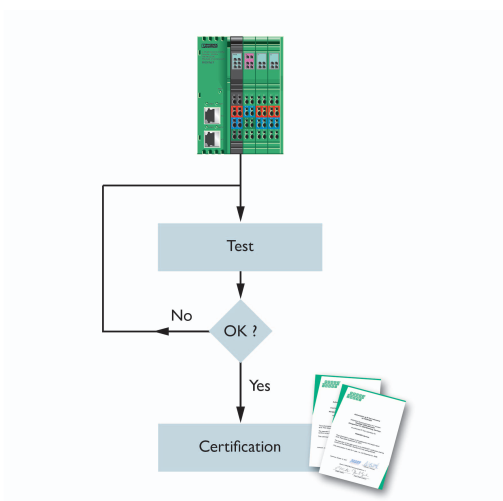

Figure 1-2 PROFINET certification

The overall test is composed of five different areas that must be covered with no exception:

- **State machine test**, ensures reproducible testing with an extendable number of test scenarios
- **Hardware test**, to ensure the PROFINET controller of the device corresponds to all applicable standards
- **Interoperability test**, so that PROFINET devices and PROFINET controllers from a range of suppliers work together seamlessly
- **GSD file test**, to check all entries in the device description file offline
- **EMC validation**, for the review of specific EMC test results

After successful testing, the customer receives an official test report, which they can then use to apply for a certificate from PROFIBUS/PROFINET International (PI). PI issues device certificates with a three year duration.

User service

With the services it offers, Phoenix Contact concentrates on the solution-oriented use of PROFINET products. The main areas of focus are planning, startup, servicing, system modernizations, and training sessions.

As one of three PROFINET International Training Centers in Germany, the PCCC is authorized to train Certified PROFINET Installers and Engineers.

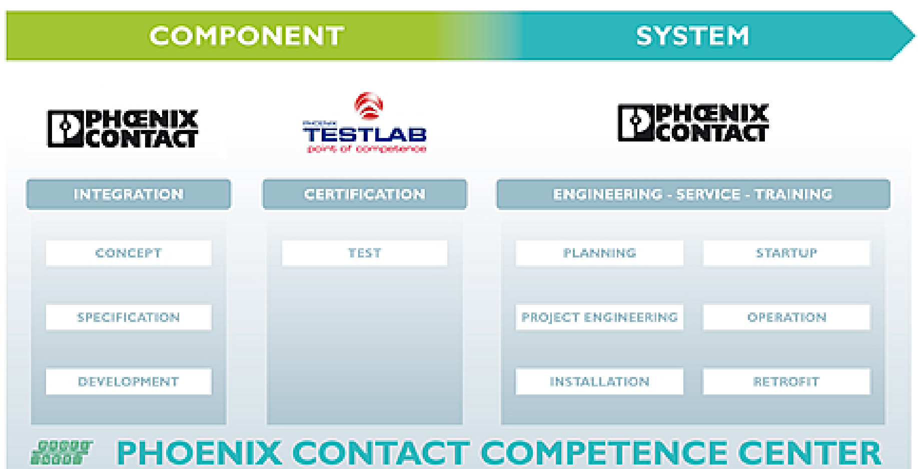

Figure 1-3 Structure of the PHOENIX CONTACT COMPETENCE CENTER

1.8 PROFINET terminology

Connecting distributed I/O devices

PROFINET is the system for connecting distributed I/O devices. The direct integration of distributed PROFINET devices to Ethernet is therefore made possible. PROFINET describes the overall data exchange between PROFINET controllers (devices with master functions) and the PROFINET devices (devices with slave functions) as well as parameterization and diagnosis.

PROFINET components

Since all Ethernet devices operate with equal rights on the network, the master-slave procedure of fieldbus technology becomes a provider/consumer model with PROFINET. The provider is the sender, which transmits the data without request to the communication partner (consumer), which then processes the data. Within the scope of PROFINET, a distinction is made between the following device types:

- A **PROFINET controller** is a controller which manages the automation task. The connected PROFINET devices are addressed via the PROFINET controller. The controller exchanges the input and output signals between the assigned field devices. The PROFINET controller receives all alarms from connected I/O devices. Furthermore, the PROFINET controller initiates complete device identification, establishing the connection, and startup parameterization of the respective devices.
- A **PROFINET device** is a field device that is controlled by a PROFINET controller. A PROFINET device consists of multiple modules and sub-modules. A PROFINET device is a distributed field device (e.g., remote I/O, drive, valve island, switch) that is assigned to one or more PROFINET controllers and that transmits not only process and configuration data, but also alarms.
- A **PROFINET supervisor** is an engineering tool for configuring and diagnosing individual PROFINET devices. Generally, the PROFINET supervisor is based on a PC. The PROFINET supervisor, which can be a programming device, for example, has access to all process and parameterization data in parallel to the PROFINET controller.

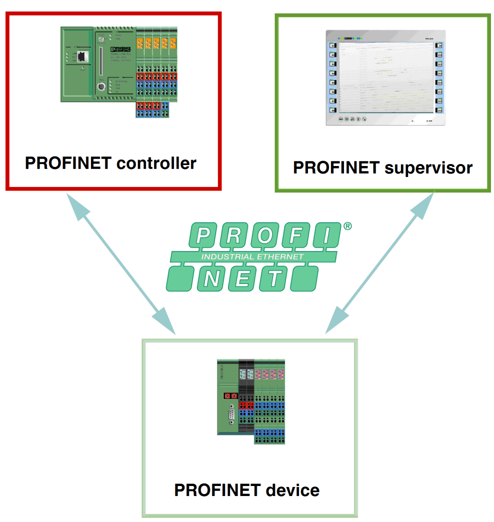

Figure 1-4 PROFINET components

PROFINET device model

The PROFINET controller uses a device model for addressing, which represents the functions of one particular field device from the viewpoint of PROFINET.

This viewpoint must be standardized for all field devices, so that communication across manufacturers and devices is possible. The PROFINET device itself defines slots into which modules can be integrated. These consist of at least one sub-module that represents the actual function.

This flexible device model is made available to the user via the device-specific GSD file. Engineering automates signal addressing.

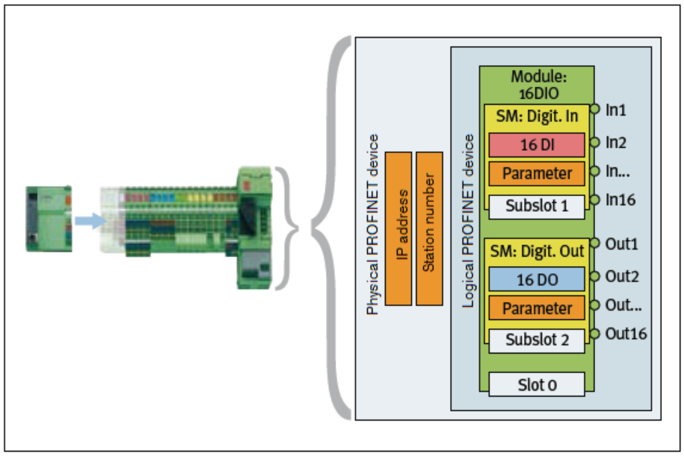

Figure 1-5 The device model functions as the particular field device from the viewpoint of PROFINET

Fast cyclical data exchange

PROFINET is designed for fast cyclical data exchange. The cyclical data telegram to one participant must not exceed the Ethernet limit of maximum 1400 byes of user data.

Cyclical update rates, which can be entered individually for each device, lie in the range of 250 µs to 512 ms. The update rates that a PROFINET controller or a PROFINET device support, however, depends on the device.

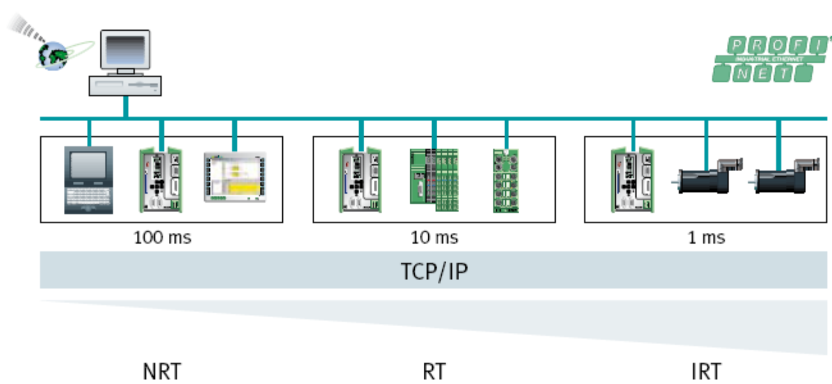

Figure 1-6 PROFINET- communication channels

Powerful acyclical communication

The communication model also enables powerful acyclical communication, in addition to cyclical data exchange, which outperforms all known key data in the fieldbuses. The potential address area as well as the parameter lengths are only limited by the storage area on the PROFINET devices and the PROFINET controllers.

TCP/IP communication

In addition to cyclical and acyclical PROFINET communication, each device also supports TCP/IP communication. Web servers or other IP-based technologies can be used on any device. At the same time, other non-PROFINET devices (such as cameras, printers, PCs) can be operated within the network.

Proxy concept

PROFINET is characterized by its subsystems which can be integrated into a consistent communication and diagnostics concept via a proxy. Field devices of a sub-fieldbus system are integrated into the PROFINET system via a proxy. The proxy in the PROFINET network is a PROFINET device; in the sub-fieldbus system it takes on the role of the master. As such, seamless integration of existing fieldbus systems into the PROFINET network is made possible. The proxy represents the subordinate fieldbus to the PROFINET system by means of mapping the data between both systems.

Based on the standardized PROFINET specification, the user can access all field devices. Double configuration or addressing on the control system and proxy side is not required. Data exchange, diagnostics, and parameterization of the proxy are carried out via the PROFINET protocol.

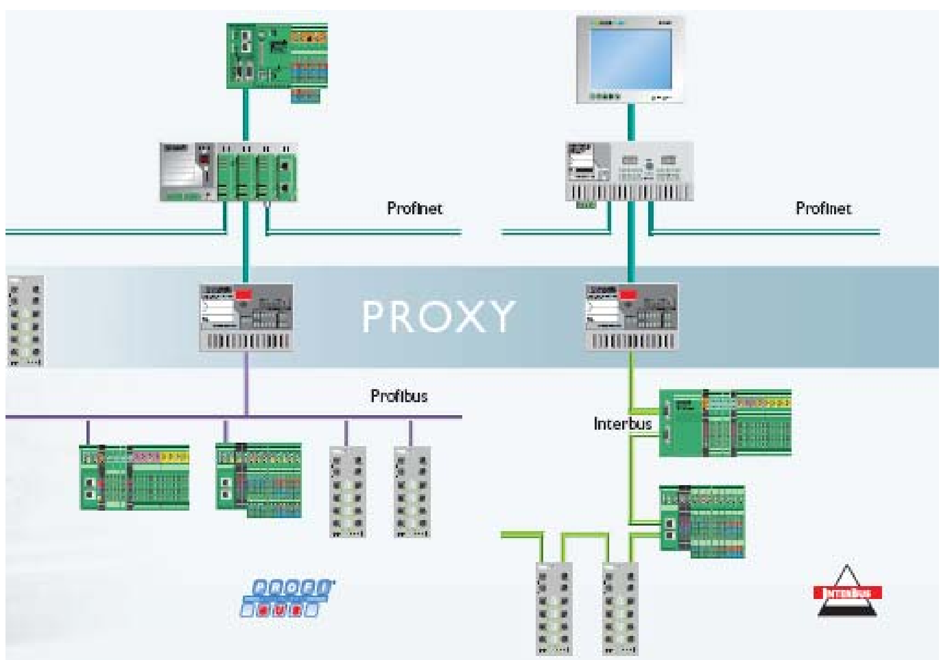

Figure 1-7 Vertical communication: PROFINET with proxies

2 PROFINET properties

Communication model

PROFINET has a very flexible yet detailed communication model. All today's automation solution requirements can be solved with PROFINET. At the same time, this model is so flexible that devices can use just the part of the standard that is required for the application case at hand.

To provide you with an insight into the basics, below, the system is described from the perspective of the communication phases (establishing connection/device parameterization), and real-time operation is introduced. With this basic knowledge, you can now more easily understand the content of Section"Installing PROFINET devices and starting up with PC Worx" on page 29.

2.1 Establishing connections and startup parameterization

To understand how connections are established, the following boundary conditions and questions must be clarified:
- How is a device type identified?
- How is a device identified in the field?
- How does the device receive the communication and device-specific startup parameters?

2.1.1 Device type identification

Each PROFINET device is marked with a device identification (device ID). The PROFINET controller transmits the device identification. When starting up, the PROFINET device checks this against the stored ID.

The device ID is structured as follows:

Vendor ID

The vendor ID is a 16-bit identifier that exhibits a unique reference to the manufacturer company. The PNO assigns the vendor ID. As such, the manufacturer company only requires the vendor ID once.

Device ID

The device ID serves to provide detailed differentiation of PROFINET devices. They are defined according to manufacturer, e.g., device class and device range.

Vendor ID	Device ID
Word (16 bit)	Word (16 bit)

As a result, each device has its own identifier. The identifier can be used, for example, to read in a network and automatically link a device description with this uniquely assigned device ID. Normally, this information does not have to be considered. When starting up the system, this is synchronized between the controller (PROFINET controller) and I/O device (PROFINET device). If the installed device does not match the configured offline device, a corresponding error message is output and establishing the connection is interrupted.

2.1.2 GSD file

Simple device description

In order to be able to integrate the components needed into an automation solution, a range of information on the device must be provided in the various engineering steps. This occurs via a device description. Each PROFINET device with its own device ID is described with a General Station Description file (GSD file). All data that is of significance for engineering as well as for data exchange with the PROFINET device is contained in this file.

GSDML

In the engineering system, the GSD file is used as the basis for planning the configuration of a PROFINET system. The properties of a PROFINET device are described by the device manufacturer in a GSD file. **GSDML** (GSD Markup Language) – an XML-based language.

Standard ISO 15745

Each manufacturer of a PROFINET device must supply a GSD file. This must also be available and be checked as part of the certification test. The GSD file is based on the ISO 15745 standard.

Within the scope of the PROFINET system, this description is imported as a GSD file in XML format into the respective engineering system. Project planning and programming is carried out in the engineering tool and then transferred to the PROFINET controller.

In comparison to the keyword-based GSD file for PROFIBUS devices, these are the following advantages of the XML-based version for PROFINET devices:

- There is a multi-dimensional description option, by entering the term sub-module.
- Multiple device types can be described in one GSD file. This depends on the implementation of the DAP (**D**evice **A**ccess **P**oint).
- There is an option to integrate multiple languages (even those that do not use the ASCII character set).
- All device-specific error texts are contained in the GSD file in multiple languages.

GSD file name

The assignment of GSD file names is standardized.

GSD [GSD formula version]-[manufacturer name]-[name of the device range]-[date].xml

Example:

GSDML-V2.31-Phoenix_Contact-AXL_F_BK_PN-V1.0-20160322.xml

The keywords described in square brackets have the following meaning:

[GSD schema version]

The GSD schema version includes the version ID of the schema used, e.g., V2.31. This version ID must correspond to the version ID in the file name of the gsd-DeviceDescription-[GSD-Schemaversion].xsd.

[Manufacturer name]

The manufacturer name corresponds to the device manufacturer name. Dashes and spaces are permitted in the name.

[Name of the device range]

The name of the device range defines which device range is described in the GSD file. Dashes and spaces are permitted in the name.

[Date]

The date of the release is displayed in the format yyyymmdd. The manufacturer ensures that GSD files that are the same, with the same date identification, are available for the same device range.

2.1.3 Device addressing in the field

MAC address

As with all other components in an Ethernet network, the PROFINET devices also have a MAC address. The devices can be clearly identified based on this address.

This address is on all devices. The MAC address is unique worldwide. It consists of twelve digits (hexadecimal). The first six digits of the MAC address represent the manufacturer. For Phoenix Contact, the ID is
00 a0 45.

PROFINET name

For PROFINET communication, it is necessary for each device to have a PROFINET name, thereby ensuring a project can be assigned correctly. All devices in a PROFINET network can be identified via these names. The PROFINET name may only appear once in the network. The name is stored in a non-volatile way directly on the device and is also available immediately after powering up.

Issue your device with meaningful or user-friendly names. In the event of diagnostics, the diagnostic tools display this name. You have the option to derive device names from the operating device designations of the respective device.

The PROFINET controller searches for the PROFINET device in the network, using the names only. If the name is not found or there are two devices with identical names in the network by mistake, an error message is output and startup is interrupted.

DNS syntax

The PROFINET name is formed according to the established DNS syntax.
Within the framework of the extension from Internet address to Unicode characters, the Punycode procedure (RFC 3492) was introduced, which converts Unicode characters to ASCII characters and vice versa. The entire character set is permitted for PROFINET names. The PROFINET name is converted into ASCII characters in the software used (e.g., PC Worx) and is sent in Punycode via the PROFINET network to the devices. When reading in unknown devices, the process is implemented in reverse in the software used, to retain a readable string once again.

Please note:
During the Punycode transformation, capital letters in PROFINET are converted to lower case. This information is lost in the reverse transformation. A reverse transformation from lower to upper case is therefore not possible.

Example:

Device name in the software	Device name in the PROFINET network	Re-transformed device name in the software
++ST001+IR001-KF70	xnxnst001xnir001-kf70abd3	++st001+ir001-kf70

PROFINET device names that do not contain any Unicode characters remain unchanged during the Punycode transformation and during the reverse transformation.

Device naming

The PROFINET device receives its PROFINET names through the device naming. From an engineering tool, the end device is identified via a flashing function or the MAC address, then the device name is written to the device.

IP address

Assigning an additional IP address is not required, as this is automatically distributed at the start when applying the settings in the project. In contrast to the PROFINET name, the IP address is only saved to the device in a volatile manner and is reassigned on every device startup by matching with the program.

2.1.4 Device parameterization during startup

After device identification, the device is assigned parameters via PROFINET. An end device remains in the network passively, until it is addressed by a PROFINET controller by name.

The communication and device-specific startup parameters are sent to the device. Only once this information is received by the device, and has been acknowledged as consistent and matching with the real hardware, can cyclical data exchange begin.

IP parameters

The IP parameters form part of the communication parameters. The IP address, subnet mask, and gateway address form part of the IP parameters. Each PROFINET device has a unique IP address. The device can be addressed via this IP address, e.g., via IT services such as FTP, HTTP, if these functions are implemented in the device.

Update rate and watchdog time

The consumer/provider communication model enables its own update rate for both directions. Furthermore, the device can be set for a watchdog time.

The update rate can accept values between 250 µs and 512 ms (PROFINET RT operating mode) or between 31.25 µs and 1 ms (PROFINET IRT operating mode). The update rate supported by a PROFINET device is determined by the GSD file. A default update rate and watchdog time are also integrated here. These parameters are also communicated to the device when the system starts up.

Startup parameters

Depending on the device structure, each device may receive further device-specific startup parameters. If these parameters affect the PROFINET device (e.g., activation of determined error classes) these are addressed at slot 0. Each subordinate slot or subslot can contain its own startup parameters.

This process of startup parameterization takes place on initial startup of a PROFINET device and after every connection interruption. The PROFINET device always receives the complete parameter record.

2.2 Real time data exchange in the operating phase

With PROFINET, the two operating modes PROFINET RT and PROFINET IRT are differentiated between during cyclical data exchange. IRT stands for isochronous real time and RT for real time. IRT and RT can be operated in parallel in a network. Addressing and troubleshooting are identical. By means of special procedures, IRT enables high synchronicity via the network. To this end, PROFINET IRT is used e.g., in highly deterministic positioning tasks.

2.2.1 Real time communication in standard cases with RT mechanisms

If establishing the connection from the PROFINET device is positively acknowledged, cyclical data exchange begins. An Ethernet telegram is sent per PROFINET device, for each data direction.

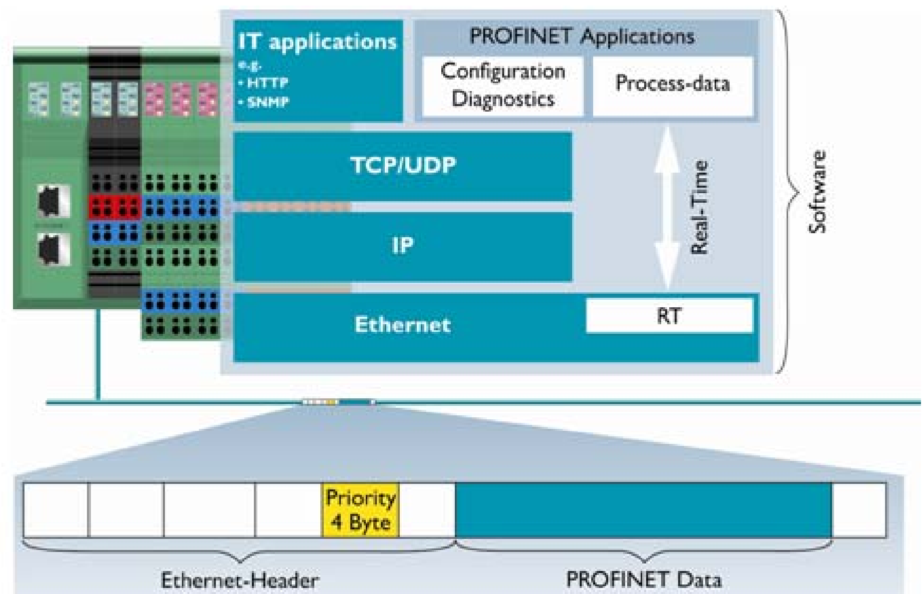

Figure 2-1 Real time communication with RT mechanisms (real time)

Prioritization

A data telegram uses the VLAN tag defined in IEEE 802.x with its prioritization information. PROFINET sets the priority to the highest level 6. The flag is used in the available switches to forward the PROFINET telegrams depending on preference. If a PROFINET telegram and a non-PROFINET telegram come in to the same switch concurrently, the PROFINET telegram is forwarded first.

The values received are forwarded via the process data channel to the application or the I/O device. This takes place with the update rate set in the connection structure. Each PROFINET device can execute its own update rate; refer to “Specifying update rates and estimating network loads” on page 32. There is no bus cycle time in the PROFINET system.

Status information

Further status information is contained in the I/O data. This status information indicates whether the device currently has an error message or reports the validity of the data. This information is automatically evaluated by the controller and the driver and is not forwarded to the user. The validity of the data is used, e.g., for the configurable replacement value behavior of the I/O signals.

RT communication fully caters for the communication requirements of today's fieldbus systems. On one network it simultaneously permits flexible startup parameterization, parallel IP communication, and powerful acyclical communication.

2.2.2 Real time communication with IRT mechanisms

IRT networks (isochronous real time) provide a deterministic data cycle precise to one µs and additional synchronization information, in particular for quick regulation processes. The communication model is identical to RT communication, e.g., device addressing, startup parameterization, and diagnostic measures are also available.

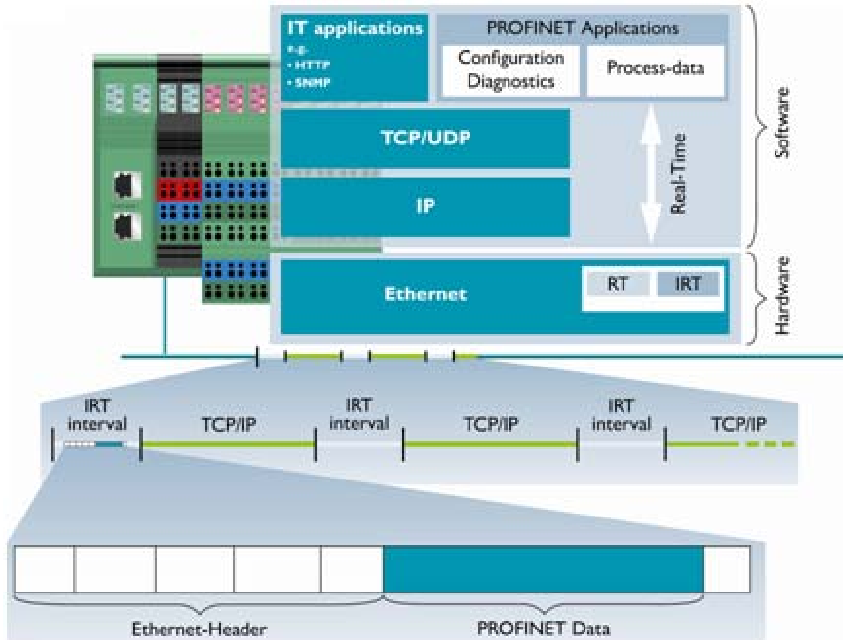

Figure 2-2 Real time communication with IRT mechanisms (isochronous real time)

The high synchronization in an IRT network is implemented in devices and switches by means of a synchronous time slice procedure. A cycle generator, the IRT Sync Master, issues a cycle in the network. The telegram runtime is calculated with runtime measurements between the devices. Real time data communication with each device is implemented in the IRT interval.

The IRT network and RT network differ on two key points. The first is that, in an IRT network, prioritization is via time slices. “Non-PROFINET data traffic” is first of all initiated or forwarded in the TCP/IP phase. If a “non-PROFINET telegram” has not yet reached its objective at the start of the IRT phase, it is saved in the device reached as an interim measure.

Second, each PROFINET telegram is planned in the network. For this purpose, transmission lists are sent to each IRT device in the startup phase, so that forwarding the telegram is just as deterministic. By doing so, in the case of jitter, PROFINET achieves precision below 1 µs.

> As the Phoenix Contact IRT controllers do not yet support this, no more details on IRT are given in the rest of the user manual. Refer to the respective data sheets as to whether I/O or infrastructure components support IRT.

2.2.3 Integrated device and network diagnostics

The PROFINET system excels, thanks to comprehensive as well as uniform network and device diagnostics. In addition to the PROFINET-specific diagnostic mechanisms, standards such as SNMP and HTTP can also be integrated into the diagnostic concept.

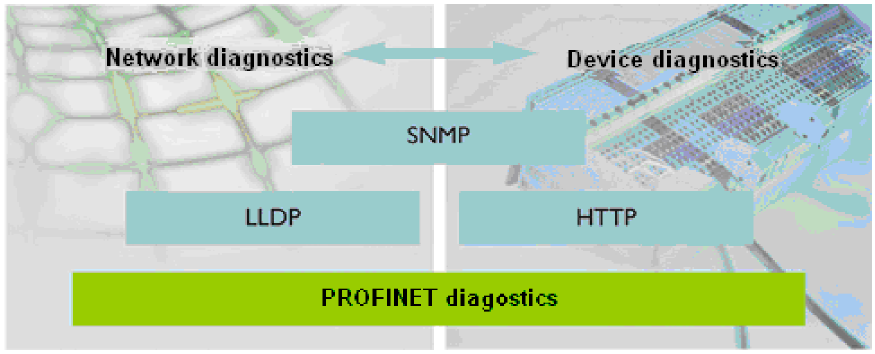

Figure 2-3 Network and device diagnostics with PROFINET

HTTP

As each device has an IP address, web-based diagnostics can be integrated into the device. The user can access the terminal device with a browser and diagnose this locally. Web-based diagnostics is almost always available on infrastructure components. In terminal devices, it is a question of the diagnostic depth which the device can report. Web-based diagnosis is optional in a PROFINET network.

SNMP

SNMP (Simple Network Management Protocol) is a global Ethernet standard for network management. Devices can send SNMP traps (alarms) to central stations, which display messages or request additional information from the device via SNMP. PROFINET defines SNMP entries in the MIB2 system group as compulsory; see also “Appendix: Frequently used terms” on page 45.

PROFINET diagnostics

As part of the PROFINET diagnostics, the PROFINET devices report an error with the cyclical I/O transfer as well as acyclically via alarms. If an undervoltage occurs, for example, on the actuator supply of the PROFINET device, an incoming alarm is sent to the controller. If the error is rectified, the controller is informed via an outgoing alarm.

Diagnostic alarm and maintenance alarm

The alarms can be divided into two groups, to take account of the increasingly important preventive diagnostics:

– Error states are generally transmitted as diagnostic alarms with corresponding parameters in standard cases.
– Signs of wear or similar information can be coded as maintenance alarms (requests for maintenance).

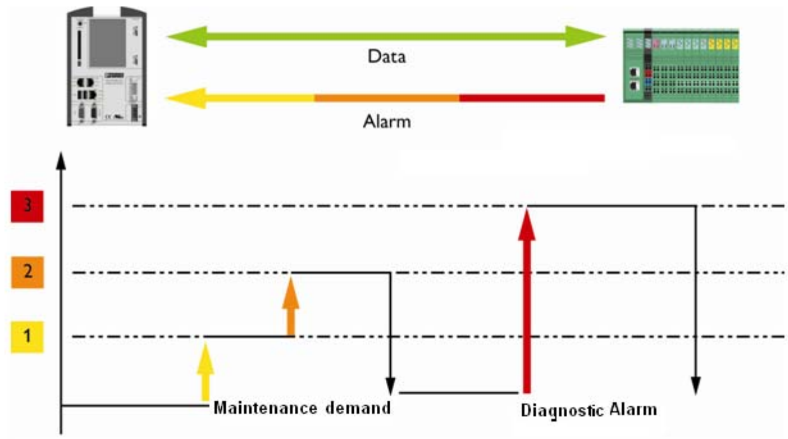

Figure 2-4 PROFINET diagnostic mechanisms

A PROFINET diagnostic tool only requires the manufacturer and device ID to locate the file and output the error message in plain text. The more detailed the error message provided by the device, the more precise the diagnostics displayed in the controller or engineering system.

Diag+

In the Phoenix Contact automation solution, the Diag+ software tool collects all diagnostic information, displays it clearly as a topology view or in a tree structure, and displays the cause of the error in plain text in multiple languages. Diag+ is an integral component of the PC Worx programming environment, but can be directly integrated as a stand-alone ActiveX solution into the visualization.

2.2.4 Topology detection

LLDP

To pinpoint the exact device location of diagnostic messages in an open network with flexible cable connections, PROFINET uses the Link Layer Discovery Protocol (LLDP). LLDP is a non-proprietary layer 2 protocol that is defined according to the IEEE-802.1AB standard and provides the option of exchanging information between neighboring devices. While the connection is being established, the devices exchange names and port numbers with neighboring components via LLDP. If all of the devices in the network support the protocol, a precise topology image can be displayed in the diagnostic tool, making it possible for the error messages to be displayed directly at the device or port.

A software component, LLDP Agent, functions on each each device that supports LLDP. The LLDP Agent sends information about itself periodically and continuously receives information from neighboring devices. These processes are entirely independent of each other. This is why LLDP is referred to as a one-way protocol which does not establish any communication with other devices.

LLDP_EXT_MIB

The information received via LLDP is stored on each device locally in a data structure, the Management Information Base (MIB). This information in the LLDP_EXT_MIB can then once again be accessed via SNMP.

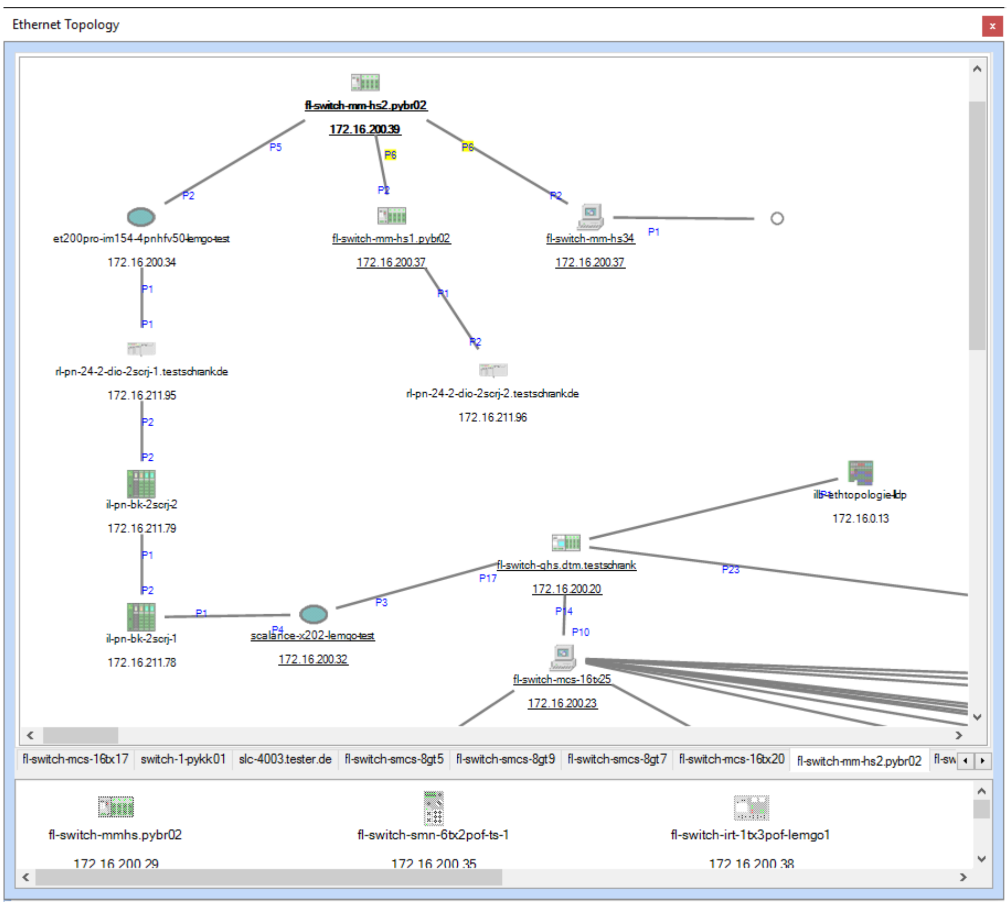

Figure 2-5 Topology detection

3 Installing PROFINET devices and starting up with PC Worx

This section describes the planning phase of your system, right through to device replacement during operation.

Perform the following steps to start up your system in the best way possible.

3.1 Planning the PROFINET system

The PROFINET network is an open network, in which other Ethernet devices can also be present. Planning a PROFINET network is therefore extremely important. Clear IP address structure, specification of the namespace, and an initial network load estimation are part of this.

3.1.1 Planning the topology

Flexible network structures

PROFINET excels, thanks to its flexible topology. PROFINET installation follows the system, that is to say, the topology is not specified by the technology. For a topology, it is a case of a point-to-point connection between the devices. The basic elements of the topology are always lines or branches. Any topology can be created from these basic elements. A special form of the line structure is the ring structure; in this, the final device is always returned to the start of the line, closing the ring. Mixed forms of the topologies are possible at any time.

If I/O devices have two ports, line structures can be established. If multiple devices are merged in one place, a switch is required, which provides the corresponding port number.

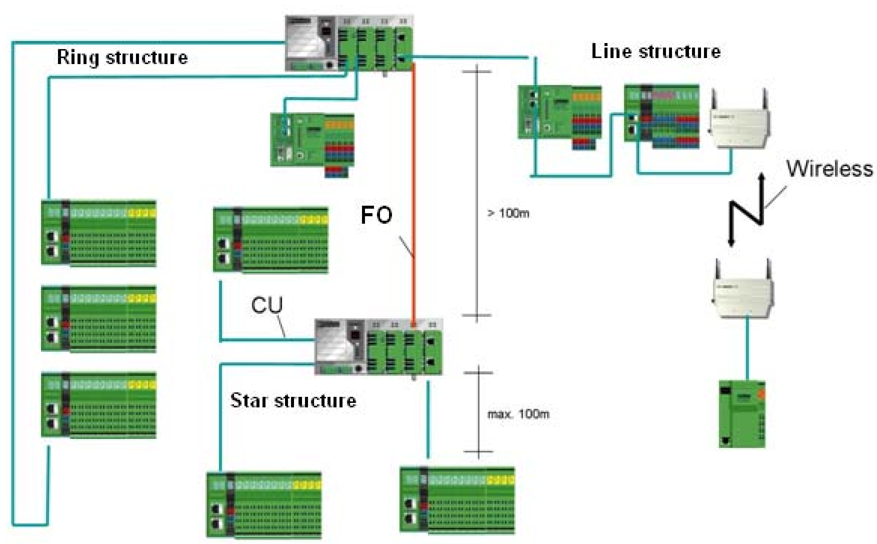

Figure 3-1 PROFINET topology example

3.1.2 Determining the transmission media

After planning the topology, determine the transmission media. PROFINET devices mostly use copper connections. Here, maximum cable lengths of 100 m are permitted. If you need to bridge longer stretches, optical transmission media can be used. Fiber optics are resistant to electromagnetic interference and permit larger network extensions than copper cable. The maximum segment lengths between two PROFINET devices is up to 14 km with fiber optics.

If moving devices are to be addressed via wireless technologies, you must route the wireless networks accordingly.

Transmission media

In accordance with requirements, in a PROFINET network:

– Communication can be set up over existing networks based on copper cables,
– Fiber optics, which are resistant to electromagnetic interference and allow networks to cover long distances, can be used,
– Wireless data transmission via WLAN and Bluetooth can be implemented.

3.1.3 Using conformance classes for planning

To support the planning of your PROFINET network, the PROFINET user organization divides the range of PROFINET functions into Conformance Classes, CC. The aim is to simplify the decision-making criteria for system operators when using PROFINET. By determining a Conformance Class, you can select field devices and bus components with clearly defined minimum features. This is a key step towards ensuring the interoperability of all field devices involved in communication. The basic functionalities such as cyclical and acyclical data exchange as well as alarms are included in all Conformance Classes as standard.

The minimum requirements for three Conformance Classes (CC-A, CC-B, CC-C) have been defined from the perspective of the system operator. In addition to the three application classes, additional specifications have been set for

– Device types,
– Communication type,
– Transmission medium used, and,
– Redundancy behavior.

Conformance Class A (CC-A)

Use of the infrastructure of an existing Ethernet network, including integration of the PROFINET basic functionality. All IT services can be used without restriction. Wireless communication is only possible in this class.

Conformance Class B (CC-B)

In addition to the scope of functions offered by Class CC-A, CC-B enables easy and convenient device replacement without an engineering tool. To increase data security, the MRP media redundancy protocol is specified as an option. Field devices in CC-B have an integrated 2-port switch.

Conformance Class C (CC-C)

In addition to the scope of functions of CC-B, CC-C enables high-precision, deterministic data transmission including synchronous applications. The integrated media redundancy makes it possible to smoothly change over the I/O data traffic in the event of an error.

The following table provides you with an overview of the properties of the conformance classes.

Property	CC-A	CC-B	CC-C
Realtime protocols	RT	RT	RT/IRT
Certified device types	PROFINET controller PROFINET device PROFINET supervisor	PROFINET controller PROFINET device PROFINET supervisor	PROFINET controller PROFINET device PROFINET supervisor
Use of standard Ethernet infrastructure	Yes, no certification required – Switches according to 802.3 – WLAN and Bluetooth Access Point/Bluetooth clients	Yes, but switches are simultaneously PROFINET devices and therefore require certification	No, PROFINET IRT-capable hardware is required in all switch components
Transmission media	Copper (100 Mbps) FO (100 Mbps) Wireless (WLAN 2.4 GHz/5 GHz, Bluetooth)	Copper (100 Mbps) FO (100 Mbps)	Copper (100 Mbps) FO (100 Mbps)
Bus synchronous applications	No	No	Yes
Validity of PROFINET cabling guidelines	No	Yes	Yes
Functions			
– **Topology detection**	No	Yes	Yes
– **Depiction in network management via SNMP**	No	Yes	Yes
Redundancy mechanisms			
– **Media redundancy meshed with RSTP/changeover 2 s**	Optional	Optional	No
– **MRP ring media redundancy/changeover 200 ms**	Optional	Optional	No
– **MRP ring media redundancy/smooth changeover**	No	No	Optional

3.1.4 Specifying the IP address

Each device in a PROFINET network has an IP address. The device receives this from the controller when starting up the system. This means that devices that cannot be reached via TCP/IP (e.g., a simple I/O station), also require an IP address. Other devices in the network (operating PCs, technology controllers, cameras, etc.) have an IP address. No IP address may be duplicated in any network.

The actual IP address, subnet mask, and gateway address form part of the IP parameters. These terms are explained in greater detail in "Appendix: Frequently used terms" on page 45.

When planning your PROFINET network, determine which IP addresses the devices have in the network. If recurring structures are detected, the IP addresses in the subnetwork can be defined according to your own specifications. The I/Os in the network have, e.g., the addresses 100 ... 125 or the "Supply" system part always has the addresses 50 ... 59.

> The planner receives the IP parameters (gateway address, subnet mask, and IP address range) directly from a network administrator when networking with superordinate networks. In the IP address range, the device responsible for automation can then normally move freely.

3.1.5 Assigning the PROFINET device name

The PROFINET device name is a very important piece of information for the controller. The terminal device is only located by a PROFINET controller by using the name. In the event of diagnostics, the name of the device is always output. It is practical to define the name during the planning phase. Here you can use, e.g., equipment identifiers or device functions (Motor1_Rotating_tower).

3.1.6 Specifying update rates and estimating network loads

PROFINET differs from established fieldbus systems in one key point. There is no bus cycle, in which e.g., the slowest device determines the speed. You can specify an individual update rate for each device, for both the input and output directions.

The update rate and the telegram length of a device are determined by the device's network load. If you do not know the network load of your system, you can calculate the network load on the busiest section in the network. This is generally the section to the controller. If additional network traffic in the management level, and e.g., additional network traffic for camera systems is also to be considered, this must also be estimated separately.

The following table indicates how much network load PROFINET devices generate with up to 40 bytes of user data.

Number of devices	Update rate in ms									
	1	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**
1	0.80%	0.40%	0.20%	0.10%	0.05%	0.025%	0.013%	0.006%	0.003%	0.002%
2	1.60%	0.80%	0.40%	0.20%	0.10%	0.050%	0.025%	0.013%	0.006%	0.003%
3	2.40%	1.20%	0.60%	0.30%	0.15%	0.075%	0.038%	0.019%	0.009%	0.005%
4	3.20%	1.60%	0.80%	0.40%	0.20%	0.100%	0.050%	0.025%	0.013%	0.006%
5	4.00%	2.00%	1.00%	0.50%	0.25%	0.125%	0.063%	0.031%	0.016%	0.008%
...										
10	8.00%	4.00%	2.00%	1.00%	0.50%	0.250%	0.125%	0.063%	0.031%	0.016%
...										
20	16.00%	8.00%	4.00%	2.00%	1.00%	0.500%	0.250%	0.125%	0.063%	0.031%
...										
30	24.00%	12.00%	6.00%	3.00%	1.50%	0.750%	0.375%	0.188%	0.094%	0.047%
...										
40	32.00%	16.00%	8.00%	4.00%	2.00%	1.000%	0.500%	0.250%	0.125%	0.063%
...										
50	40.00%	20.00%	10.00%	5.00%	2.50%	1.250%	0.625%	0.313%	0.156%	0.078%
...										
100	80.00%	40.00%	20.00%	10.00%	5.00%	2.500%	1.25%	0.625%	0.313%	0.156%

The following table indicates how much network load PROFINET devices generate with up to approx. 100 bytes of user data.

Number of devices	Update rate in ms									
	1	2	4	8	16	32	64	128	256	512
1	1.60%	0.80%	0.40%	0.20%	0.10%	0.050%	0.025%	0.013%	0.006%	0.003%
2	3.20%	1.60%	0.80%	0.40%	0.20%	0.100%	0.050%	0.025%	0.013%	0.006%
3	4.80%	2.40%	1.20%	0.60%	0.30%	0.150%	0.075%	0.038%	0.019%	0.009%
4	6.40%	3.20%	1.60%	0.80%	0.40%	0.200%	0.100%	0.050%	0.025%	0.013%
5	8.00%	4.00%	2.00%	1.00%	0.50%	0.250%	0.125%	0.063%	0.031%	0.016%
...										
10	16.00%	8.00%	4.00%	2.00%	1.00%	0.500%	0.250%	0.125%	0.063%	0.031%
...										
20	32.00%	16.00%	8.00%	4.00%	2.00%	1.000%	0.500%	0.250%	0.125%	0.063%
...										
30	48.00%	24.00%	12.00%	6.00%	3.00%	1.500%	0.750%	0.375%	0.188%	0.094%
...										
40	64.00%	32.00%	16.00%	8.00%	4.00%	2.000%	1.000%	0.500%	0.250%	0.125%
...										
50	80.00%	40.00%	20.00%	10.00%	5.00%	2.500%	1.250%	0.625%	0.313%	0.156%
...										
100	-	80.00%	40.00%	20.00%	10.00%	5.000%	2.500%	1.250%	0.625%	0.313%

The resulting accumulated network load determines how high the power level of your controller needs to be. If the controller can no longer process these network loads, reduce the update rates of the devices or use a more powerful controller. You also have the option of distributing the controller program across multiple controllers.

3.2 Configuring the network

Now transfer the results of your planning into the prepared project.

3.2.1 Performing preliminary measures in PC Worx

Communication

In the "Extras, PROFINET Configuration..." menu in PC Worx, select the network card for your PC that is to be used for communication.

Creating a project

If no project exists yet, create this first of all under PC Worx. Select the "New Project…" command from the "File" menu.
Then select the PROFINET controller available.

Project parameters

In the bus configuration workspace, you can adjust the project information to suit the project. If you select the nodes of the PROFINET controller in the "Bus Structure" window, you can change the IP settings in the "Device Details" window, for example.
Also prepare your PC for communication. To do so, select the IP parameters of the PC in such a way that communication can take place with the connected network.

Importing external devices

Devices that are not included in the device catalog can be transferred into the device catalog using the "Import GSD File..." function (right click). The device is then transferred into the device catalog under the respective company name.

> Further information can be found in the quick start guide "Installing and starting up the AXC 1050 PN STARTERKIT" UM QS EN AXC 1050 PN STARTERKIT. It can be downloaded at phoenixcontact.net/products.

3.2.2 Configuring PROFINET devices

In this step, using drag-and-drop, drag the PROFINET device from the "Device Catalog" to the PROFINET nodes of the controller in the "Bus Structure" window. The corresponding settings, such as device name, IP address, and update rate/monitoring time are automatically set with default values and should be adjusted under the "PROFINET Settings" tab in the "Device Details" view, so as to display the planned names and addresses.

In addition to the update rate, you can also set a monitoring time for each connection, which leads to loss of the connection if this is exceeded. A multiplication of the transmission rate is set. The lowest setting for this is 3.

The following additional device parameters influence the system behavior of the controller and can be set specifically for each PROFINET device.

- Actuate the PNIO_SYSTEM_BF system variable
- Log connection state
- Operation in case of configuration differences

> Further information can be found in the quick start guide "Installing and starting up the AXC 1050 PN STARTERKIT" UM QS EN AXC 1050 PN STARTERKIT. It can be downloaded at phoenixcontact.net/products.

3.2.3 Integrating Ethernet devices into the project

For IP addresses to remain unique in the network, Ethernet devices such as PCs or Ethernet infrastructure components can be integrated into the project as placeholders. To do so, using drag-and-drop, drag these devices from the “Device Catalog” window to the “Bus Structure” window on the controller level. Ethernet and wireless infrastructure components from Phoenix Contact can be found in the “Device Catalog” window, right under the FL (Factoryline) device range. The “Windows PC” device can be used as a placeholder for other Ethernet devices, from the “Generic” range.

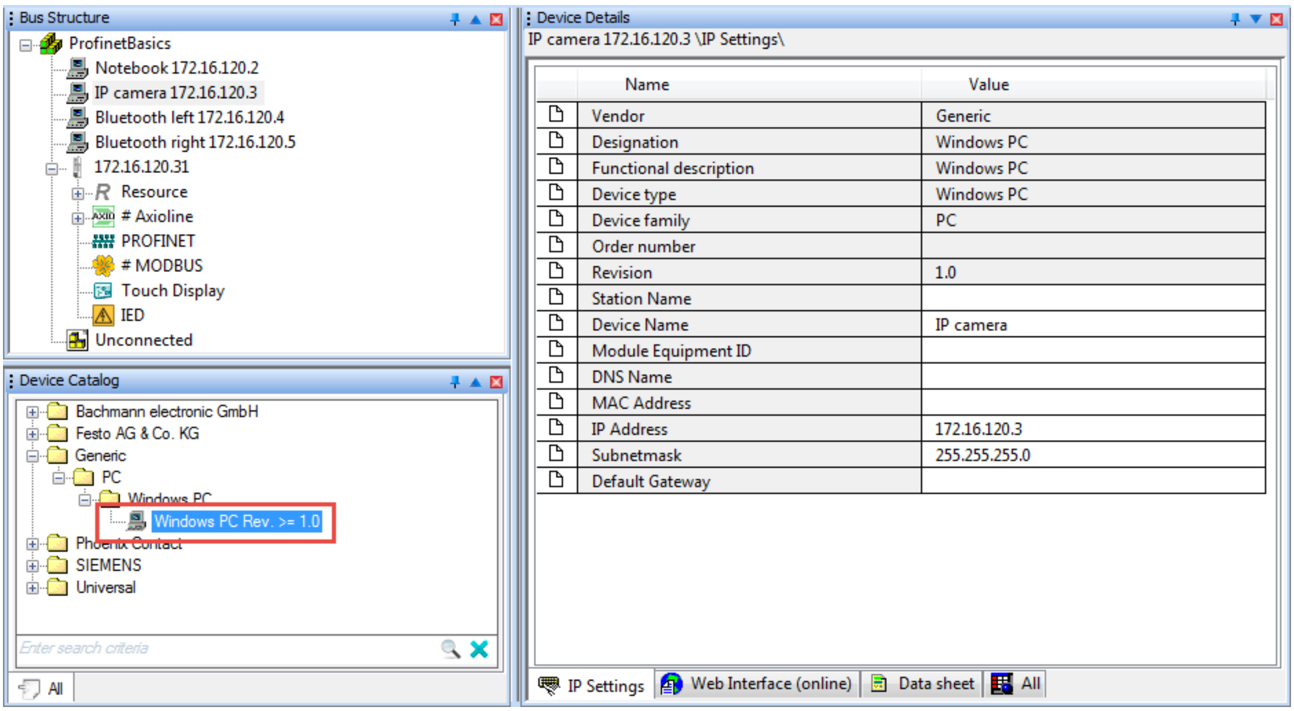

Figure 3-2 “Windows PC” placeholder

3.2.4 Checking the controller performance

To check the performance of the selected controller, you have to compile the project once. If no further error message has been output, in addition to the “Program missing” error, the controller key data has not been exceeded.

3.3 Starting up the network

In order for the controller to be able to start up the network, first of all, all device names must be written to the devices. This “device naming” can be done directly from PC Worx or using other tools.

> It is practical to name devices before carrying out the electrical device installation. At this point in time, the device has a clear assignment and you can name it, without confusing it with other devices.

To uniquely identify the device, you can use the MAC address printed on it. The additional safety results in “flashing”. Individually addressed devices flash with their display instruments, such as LEDs, if they are searched for by a PROFINET engineering tool in the system.

3.3.1 Assigning device names with NetNames+

The NetNames+ tool from the AUTOMATIONWORX Software Suite provides you with an easy way to assign device names.

Find the tool under via “Start, All Programs, Phoenix Contact, AUTOMATIONWORX Software Suite..., Tools”. After selecting the network card, this tool provides a quick overview of all PROFINET devices available in the subnetwork, even without PC Worx. You can assign names and write multiple names concurrently. IP addresses can also be assigned, in order to be able to address the device websites e.g., in the startup phase.

The import list provides a special function. NetNames+ can import all names from a planning tool with a simple import list. These names can be assigned to the devices identified via drag-and-drop. There is no need to manually type in the device names.

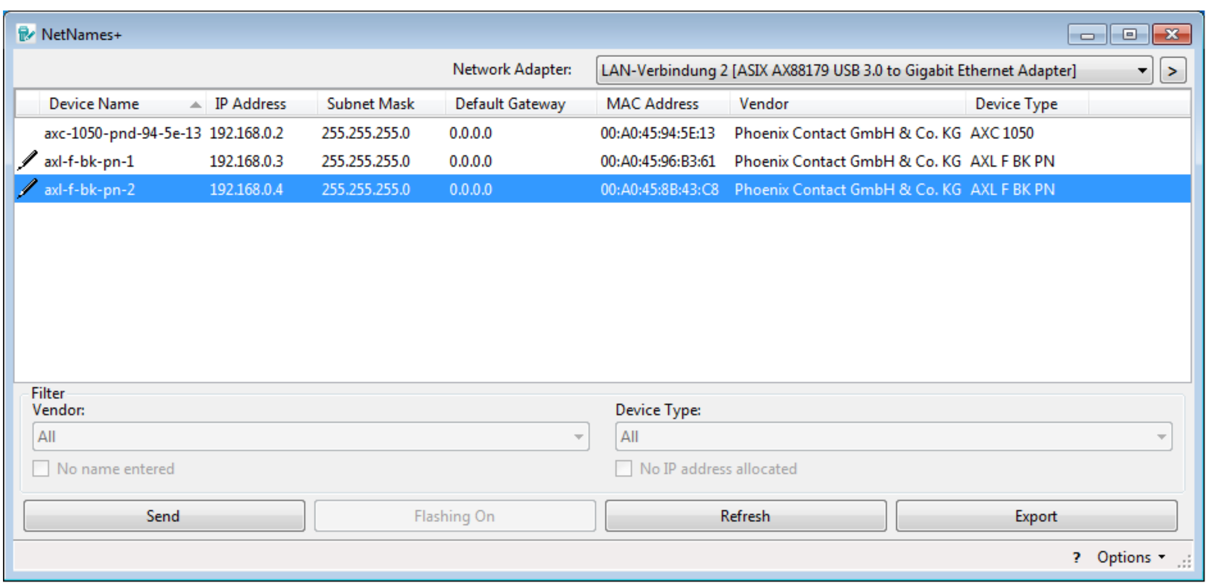

Figure 3-3 Changing device names

A detailed description of the functions can be found in the online help for NetNames+.

Reading in the configuration

To launch PC Worx and create a new project or open an existing one, refer to “Performing preliminary measures in PC Worx” on page 35. In the bus configuration workspace in the “Bus Structure” window, select the PROFINET nodes of the controller. Select “Read PROFINET...” in the context menu. Using this function, all PROFINET devices in the network can be located.

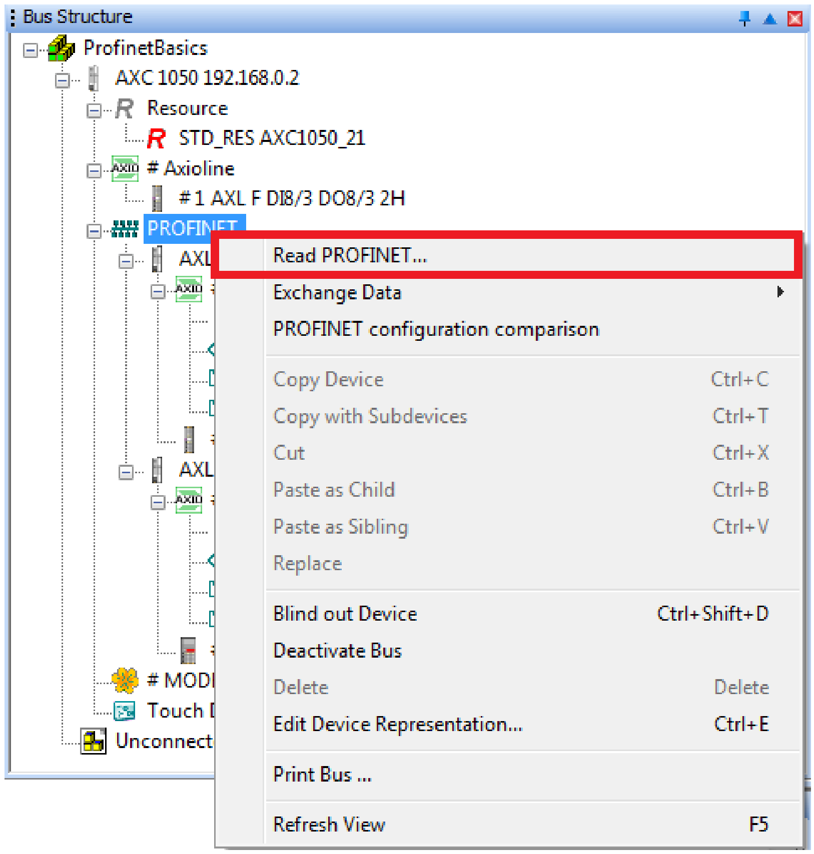

Figure 3-4 Read PROFINET

All the connected PROFINET devices are displayed.

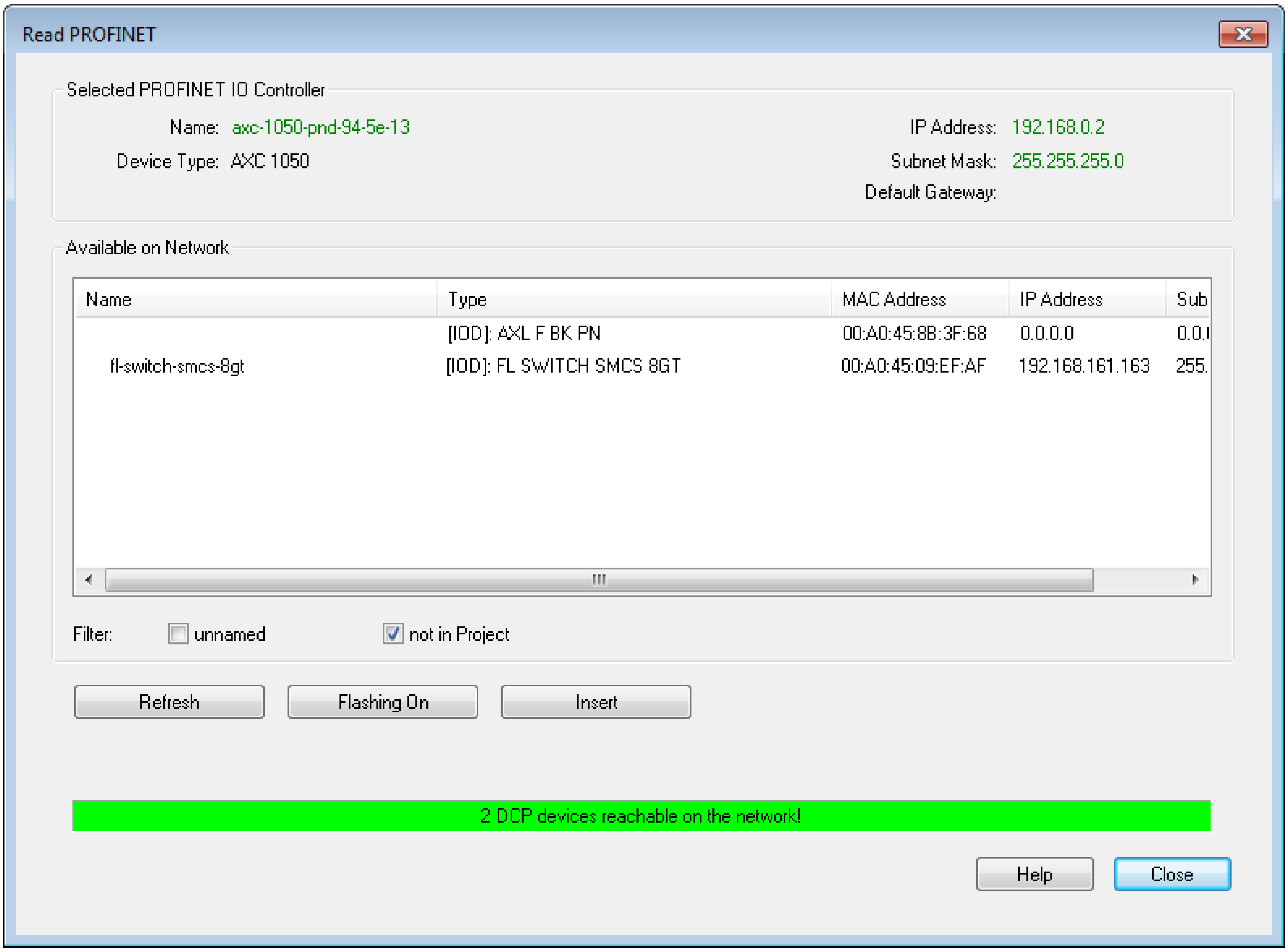

Figure 3-5 Inserting PROFINET devices

In the “Read PROFINET” window, selected devices can be transferred to the current project using the “Insert” button.

Different options are available for limiting the search results:

– No restriction
  All devices that are available in the network are listed.
– unnamed
  All those devices that do not yet have a PROFINET device name are listed.
– not in Project
  All those devices that are not included in the project are listed.

The devices are clearly assigned using their MAC address. Furthermore, you have the option of allowing the LEDs to flash on a selected device. To do so, select a device and click on the “Flashing On” button.

When transferring the devices into the project, a device name is automatically generated and the device is named. You also have the option of assigning another, individual name.

Manually assigning a name

If a project has already been created, it contains all the settings required for communication as well as the device names. These have to now be assigned to the devices available.

In the “Bus Structure” window, select the nodes of the PROFINET device that are now to be assigned a name. In the “Device Details” window, under “PROFINET Stationnames”, all the PROFINET devices available in the network are displayed.

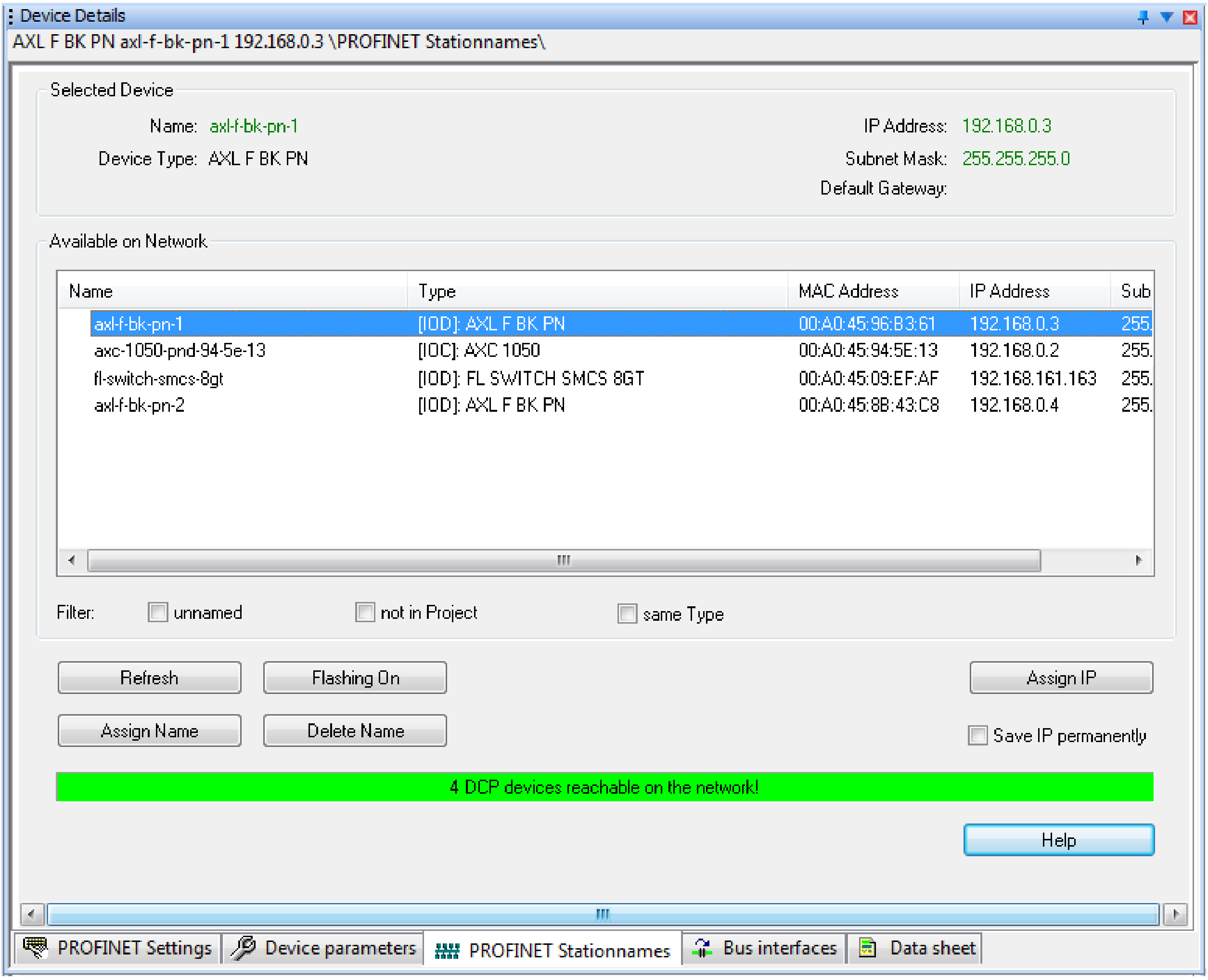

Figure 3-6 Displaying the PROFINET devices

In order to limit the search results, different options are available here too:

– No restriction
  All devices that are available in the network are listed.
– unnamed
  All those devices that do not yet have a PROFINET device name are listed.

– not in Project
  All those devices that are not included in the project are listed.
– same Type
  Only those devices are listed that correspond to this device type.

Based on your MAC address, the devices that are in the network can be clearly identified. Select the desired device and then click on the “Assign Name” button. This issues the device with a PROFINET name.

Another way to identify devices in the system is provided by the “Flashing” function. To apply this, select a device in the network and click on the “Flashing On” button. Now you can locate the device based on the flashing LEDs in the system.

This step must be repeated for each device in the project.

3.3.2 Observing startup behavior

Starting up the controller is the easiest way to check whether
– The controller is correctly parameterized,
– The I/O devices have the right name
– There are double names or double IP addresses in the system.

Compile the project. There will be a warning message if there is no application program. You can ignore this message.

Make sure that the controller has the IP address that was set in the project. To do so, start the “Project Control Dialog” via the menu bar.

If the message “Timeout” appears after 10 seconds, the project and device addresses do not match. It is also possible that the IP address of the PC has not been set correctly.

Using the “Project Control Dialog”, you can reset the controller. Existing projects are deleted. Start the download and perform a cold restart. Afterwards the BF LEDs must go out on all devices.

To access the network status from the program, the following system variables are mapped in the global variables of the programming environment.

Global variable	Type	Description
PNIO_CONFIG_STATUS_ACTIVE	BOOL	Connection to these devices is being established or has been completed.
PNIO_CONFIG_STATUS_READY	BOOL	Connection establishment to the devices has been completed.

If you require more detailed information, the Diag+ diagnostics tool can be called up from PC Worx via the “View, Diag+” menu. Diag+ connects to the controller, and you receive further information; refer to Section3.4.3 on page 44 .

3.4 Network in operation

3.4.1 Automatic startup following device replacement

PROFINET addresses each device via a name. If a device is replaced, this name must be transferred to the new component. In the PROFINET system, the controller detects a device replacement based on the topology information and writes the name of the replaced components automatically, within a few seconds, to the new device.

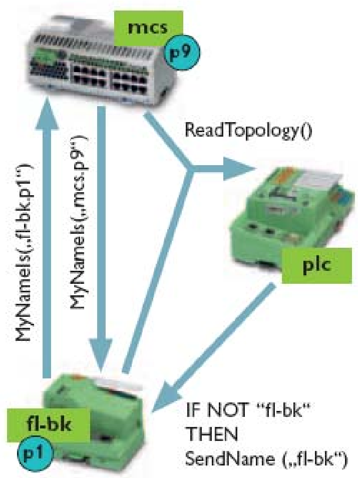

Figure 3-7 Automatic startup following device replacement

In order for topology detection to function successfully, some basic prerequisites must be fulfilled:

– It is essential for the PROFINET devices to support LLDP.
– For the automatic name assignment function to work when a device is replaced, the topology must not be changed by the replacement. This implies that a defective device can only be replaced by a device of identical type, and only in the same place.

It is important that the PROFINET controller remains in operation after device failure. If this is not the case, the information on neighborhood detection is lost. Then the device must be manually renamed with the PROFINET name.

> If devices in a system are replaced with one other, this leads to problems. All names are defined in the project; as such no device can be added and no device can be missing. The system takes this state to mean a changed topology. PROFINET communication begins without changing the names of the devices.

3.4.2 Diagnostic variables in the controller

PROFINET provides extremely detailed diagnostic information from each device down to the channel.

Diagnostic states are important for system operation. If error messages occur, the process has to be stopped in case of doubt. To this end, AUTOMATIONWORX controllers provide the following status information for the PROFINET network.

Global variable	Type	Description
PNIO_SYSTEM_BF	BOOL	An error occurred in the PROFINET network; that means that there is no connection to at least one configured device. This value is not set if the “Control BF” parameter is set to FALSE for a device. These devices have therefore been excluded from connection monitoring.
PNIO_SYSTEM_SF	BOOL	At least one device reported a system error (diagnostic alarm or maintenance alarm).
PNIO_DIAG_AVAILABLE	BOOL	At least one device reported a diagnostic alarm with an active connection.
PNIO_MAINTENANCE_DEMANDED	BOOL	At least one device reported the “maintenance request” alarm with an active connection.
PNIO_MAINTENANCE_REQUIRED	BOOL	At least one device reported the “maintenance demand” alarm with an active connection.

If one of these variables is set, it is now possible to decide from the program whether the system should continue operating. System errors of the “Maintenance required” type and “Maintenance demanded” can only lead to a message being sent to service personnel. Personnel is advised of the failure location, reason, and urgency.

If the application of each device is to be monitored for diagnostics, then the automatically generated signals of the PNIO_DATA_STATE structure can also be used.

Global variable	Type	Description
PNIO_DATA_VALID	BOOL	The application program must receive information on whether a PROFINET device is supplying valid data or not. This is why each PROFINET device has a PNIO_-DATA_VALID process data item. This bit must be set for the PROFINET device to supply valid data and all other process values to be valid.
PNIO_NO_DIAG	BOOL	If this bit is set, there are no device diagnostics present.

3.4.3 Diagnostics via alarm blocks

So that the error messages from the previous section can be displayed in a practical way on the servicing level, troubleshooting can be read by each device by means of the RALRM block.

The block requires the ADDRESS_TO_ID function to identify the end device. The RALRM block can call up the diagnostic message with the communication ID. In contrast to Diag+, the block does not receive any error texts; instead it only emits binary information. These include the slot number, subslot number, channel number, and error cause.

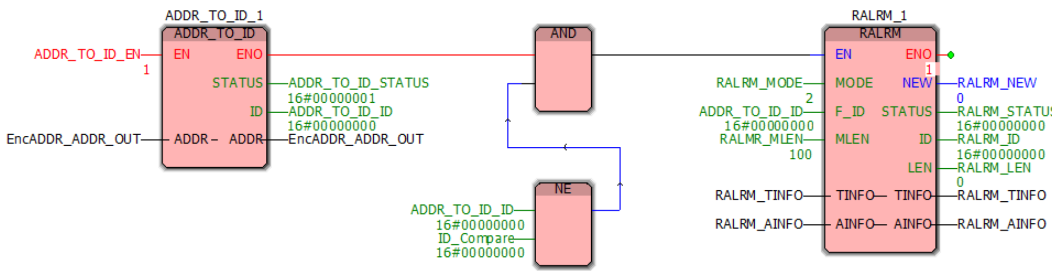

Figure 3-8 Alarm block

Further information on alarm blocks can be found in the PC Worx online help.

3.4.4 Diagnostics via Diag+

If an error occurs, the Diag+ tool from PC Worx or another program can be launched from this at any time. Diag+ must first of all connect to the controller, then various diagnostic views can be called.

PROFINET diagnostics

The PROFINET diagnostics displays all PROFINET devices in a tree structure. Devices marked in red are faulty. If the device is opened, all slots of the device are displayed with the exact error localization and error cause. The cause of the error is prepared as textual information if the GSD file of the terminal device is available on a PC. This view displays the current error status. A history can be found in the diagnostic archive.

Ethernet topology

The Ethernet topology displays the device and cable state generated in PC Worx (network target state). In this network depiction, further information on the devices, such as error states, hardware/firmware states or accessibility can then be displayed. PROFINET and Ethernet devices have the same rights.

Diagnostic archive

The diagnostic archive collects all error messages (not just PROFINET) that are sent to the controller. Specific processes can be displayed at a later date via a time stamp and comprehensive filter criteria. The archive is a ring buffer; after reaching the thresholds of the oldest information, this is then overwritten.

A Appendix: Frequently used terms

10Base-T

Ethernet twisted pair cabling with 10 Mbps transmission speed. 10Base-T runs over four wires (two twisted pairs) of a CAT3 or CAT5 cable. The maximum length of a segment is 100 m.

100Base-T

Fast Ethernet twisted pair cabling with 100 Mbps transmission speed. As with 10Base-T, 100Base-T uses a twisted wire pair per direction, but requires at least an unshielded CAT5 cable. The maximum length of a segment is 100 m, as with the 10Base-T.

ARP (Address Resolution Protocol)

The Address Resolution Protocol (ARP) enables the assignment of network addresses to hardware addresses. Although it is not restricted to Ethernet and IP protocols, it is almost exclusively used in conjunction with IP addressing in Ethernet networks.

Autocrossing

Autocrossing is a method that automatically crosses the transmit and receive lines to twisted pair interfaces (if necessary). Autocrossing means it is not necessary to make a distinction between 1:1 and crossover cables. This prevents malfunctions in the case of interchanged transmit and receive lines.

Autonegotiation

In autonegotiation mode, an Ethernet device automatically sets itself to the data transmission speed (10 Mbps or 100 Mbps) of the device it is connected to.
Furthermore, the transmission mode (full/half duplex) is agreed.

BootP (Bootstrap Protocol)

The Bootstrap Protocol (BootP) serves to assign an IP address and a range of further parameters in a TCP/IP network. BootP has many parameters; in particular, subnet masks, gateways, and BootP servers can be transferred.

DCP (Discovery and basic Configuration Protocol)

It is obligatory to use the Discovery and basic Configuration Protocol (DCP) for assigning IP addresses and names in a PROFINET system.

DHCP (Dynamic Host Configuration Protocol)

The Dynamic Host Configuration Protocol (DHCP) is an extension to the Bootstrap protocol. It makes it possible to assign a corresponding dynamic IP address and other configuration parameters on computers in a network (e.g., Internet or LAN) using an appropriate server.

DTM (Device Type Manager)

FDT/DTM is a non-proprietary concept which enables parameterization of field devices from various manufacturers with only one program.

ERTEC (Enhanced Real Time Ethernet Controller)

The Enhanced Realtime Ethernet Controller (ERTEC) is envisaged for PROFINET devices with RT and IRT functionality. With the integrated processor, the Ethernet Switch with integrated PHYs and the option of connecting an external host processor system to a local bus interface, it provides all prerequisites for the implementation of PROFINET devices with integrated switch function.

FDT (Field Device Tool)

FDT/DTM is a non-proprietary concept which enables parameterization of field devices from various manufacturers with only one program.

FTP (File Transfer Protocol)

The File Transfer Protocol (FTP) is a network protocol specified in 1985 for transferring files via TCP/IP networks. FTP is located in the Application Layer (layer 7) of the OSI model. It is used to transfer files from the server to the client (download), from the client to the server (upload) or to transfer client-based between two servers. Furthermore, with FTP, directories can be created and files can be renamed or deleted.

Gateway address
Address of the default gateway. All telegrams that are not addressed to devices in the same subnetwork are forwarded via the default gateway.

Device model
To structure a PROFINET device, a standardized device model is specified, which makes modeling modular and compact field devices possible. The device model consists of slots and subslots. Slot 0 is always reserved for the bus interface.

GSD (Generic Station Description)
Each manufacturer of a PROFINET device must supply a corresponding GSD file. As with PROFIBUS DP, the properties of the PROFINET device are described in this file. However, unlike this, the file is not in a keyword-based text file, but an XML file. In conjunction with PROFINET, the term Generic Station Description Markup Language (GSDML) is also used.

HTTP (Hypertext Transfer Protocol)
The Hypertext Transfer Protocol (HTTP) is a protocol for transmitting data over a network. It is primarily used to load web pages and other data from the Internet in a web browser.

HTTP is part of the Application Layer of established network models. The Application Layer is addressed by the application programs; in the case of HTTP, this is usually a web browser. In the OSI layer model, the Application Layer corresponds to layers 5 ... 7. The TCP/IP reference model used on the Internet sees the Application Layer in layer 4.

Hub
A hub is a networking component that regenerates Ethernet signals from layer 1 of the OSI model as Ethernet star couplers. The signals are forwarded to all ports.

PROFINET controller
Device via which all connected PROFINET devices are addressed.

PROFINET device
Distributed field device that is assigned to one or more PROFINET controllers and that transmits not only process and configuration data, but also alarms.

PROFINET supervisor
A programming device or industrial PC that has access to all process and parameterization data in parallel to the PROFINET controller.

IP (Internet Protocol)
The Internet Protocol (IP) is a widely used network protocol in computer networks. It is the implementation of the Internet layer of the TCP/IP reference model or the Network Layer of the OSI model.

The Internet protocol generates the first independent layer of the Internet protocol family from the transmission medium. This implies that by means of an IP address and subnet mask, computers can be grouped into logical units within a network. On this basis it is possible to address computers in larger networks and establish connections to them, as the logical addressing is the basis for routing (path selection and forwarding of network packets). The Internet protocol forms the basis of the Internet.

IP address (Internet protocol address)
An Internet protocol address (IP address) is used to uniquely address computers and other devices in an IP network. Technically speaking, the number is a 32- or 128-digit binary number. The Internet is the most common network in which IP addresses are used. There, for example, web servers are addressed via IP addresses (all computers on the Internet are addressed via an IP address). In functional terms, the IP address corresponds to a telephone number in a telephone network.

The IP address consists of four decimal figures with the value range of 0 ... 255. These are separated from each other with a period. The IP address consists of:
- The address of the subnetwork
- The address of the device (generally also called the host or network node).

IRT protocol (Isochronous Realtime Protocol)
The Isochronous Realtime Protocol (IRT protocol) is used for PROFINET applications with a cycle time less than 10 ms.

LLDP (Link Layer Discovery Protocol)

Link Layer Discovery Protocol (LLDP) is defined according to the IEEE-802.1AB standard. Via LLDP, the individual MAC address, device name, and port number are replaced with that of the direct neighbor for neighborhood detection.

For each device that supports LLDP, the LLDP Agent sends it information about itself at periodical intervals and continuously receives information from neighboring devices. These processes are entirely independent of each other. This is why LLDP is referred to as a one-way protocol which does not establish any communication with other devices.

The information received via LLDP DUs (Data Units) is stored on each device locally in a data structure, the Management Information Base (MIB). This information can then once again be accessed via SNMP.

LLDP messages are transmitted in a Layer-2 Frame (OSI model) to the multicast address "01:80:C2:00:00:0E".

MAC (Media Access Control)

Media Access Control or Medium Access Control (MAC) is an extension (created by the Institute of Electrical and Electronics Engineers (IEEE)) of the Open Systems Interconnection Reference Model (OSI model). The IEEE divides the two lowest layers of the seven in the OSI model into the sublayers Media Access Control and Logical Link Control, whereby the MAC is the lower of the two.

The OSI model assigns the hardware and software components required in a computer network to a total of seven layers of increasing complexity. The higher a layer is, the less interested it is in the technical process of data transmission and the more it is concerned with the actual content of the data. The MAC is the second-lowest layer and includes network protocols and components that control how multiple computers share the joint physical transfer medium. It is necessary because a shared medium cannot be used simultaneously by several computers, without data collisions in either the short or long term, resulting in communication errors or data loss. In the original OSI model, such concurrence for the communication medium was not envisaged, why is why MAC is not included in this.

MAC address (Media Access Control)

The MAC address (Media Access Control, Ethernet ID or, in the case of Apple, Airport ID) is the hardware address of each network adapter, used to uniquely identify the device within the network.

Each PROFINET device is assigned a device identifier that is unique across the world, from the date of manufacture. This device identifier, 6 bytes long, is the MAC address.

The MAC address is made up of:

– 3 bytes of manufacturer ID and
– 3 bytes of device ID (sequential number)

The MAC address can generally be read off the device.

The MAC address is assigned to the Data Link Layer, layer 2 of the OSI model. In order to connect the Data Link Layer with the Network Layer, the Address Resolution Protocol is used, for example, in the case of Ethernet.

Network devices then need a MAC address, if they are to be explicitly addressed on layer 2, to be able to offer services to higher layers. If the device, as in the case of a repeater or hub, only forwards network packets, it is not visible on the Data Link Layer and as a result does not require a MAC address. Bridges and switches examine the packets of the Data Link Layer to physically partition the network into multiple collision domains, but do not actively participate in the communication itself, so they do not need a MAC address either.

A switch only requires one MAC address if it is manageable or offers monitoring services (e.g., via Telnet, SNMP or HTTP). Bridges use the MAC address for the spinning tree algorithm.

PDev (Physical Device Object)

The Physical Device Object (PDev) represents the hardware of a device. For a PROFINET controller, there is exactly one PDev per runtime. The PDev can be reached via the IP address of the device and functions as the first contact point for other applications for navigating through the device.

PHY

A special semiconductor device or a functional group of a circuit, which is responsible for the coding and decoding of data between a purely digital system and a modulated system, is referred to as PHY. PHY therefore stands for physical interface. A PHY semiconductor is usually used on Ethernet devices. It provides digital access to the channel operated on a modulated basis (Ethernet).

PTCP (Precision Transparent Clock Protocol)

The Precision Transparent Clock Protocol (PTCP) according to IEC 61158, is a process for precise time synchronization and is used for PROFINET IRT.

Synchronization is staggered, that is, a clock master (usually the PROFINET controller) determines the common clock system and sends out "sync frames" for synchronization. The other IRT PROFINET devices synchronize their local clock system to this master clock. A clockmaster sends a synchronization frame to all involved clock slaves.

To synchronize the participants to a common clock, it is necessary to determine the "line delay" between neighboring nodes and the actual synchronization.

RARP (Reverse Address Resolution Protocol)

The Reverse Address Resolution Protocol (RARP) enables the assignment of network addresses to Internet addresses. It belongs to the network layer of the TCP/IP protocol range. RARP is not used if the IP address of the computer is not known.

RSTP (Rapid Spanning Tree Protocol)

The Rapid Spanning Tree Protocol (RSTP) is also widely used outside PROFINET applications. It does not provide any guaranteed switching times. As a result, complex network structures are controlled, which go far beyond a simple ring structure.

Just one incorrect Spanning Tree Frame is in the position to trigger a reorganization and to stop the entire network for 30 seconds or more. To avoid this scenario, the downwards compatible RSP, also known as Fast Spanning Tree, was developed, under IEEE 802.1w. It provides for the case of a connection failure with the existing network structure until an alternative route is calculated. A new logical tree is created, and only then is it changed, within one second.

The process of transferring RSTP to IEEE 802.1d began in 2004. As part of this, there have been continued improvements, e.g., the support of up to 160 switches and reconfiguration times < 500 ms.

RT protocol (Realtime Protocol)

The Realtime Protocol (RT) is used for PROFINET applications with a cycle time larger than 10 ms.

Slot

A slot describes the structure of the components or functions, such as hardware modules or logical units, within a PROFINET device. A slot can have multiple subslots.

SNMP (Simple Network Management Protocol)

The Simple Network Management Protocol (SNMP) is a network protocol developed to monitor and control network elements (e.g., routers, servers, switches, printers, computers, etc.) from a central station. The protocol controls communication between the monitored devices and the monitoring station. For this purpose, SNMP describes the structure of the data packets that can be sent and the communication sequence. SNMP was designed in such a way that each network-capable device can be incorporated into the monitoring. The network management tasks that are possible with SNMP include:

– Monitoring of network components
– Remote control and remote configuration of network components
– Error detection and error notification

STP (Spanning Tree Protocol)

The Rapid Spanning Tree Protocol (STP) is also widely used outside PROFINET applications. This procedure does not provide any guaranteed switching times. As a result, complex network structures are controlled, which go far beyond a simple ring structure.

The Spanning Tree process is specified in the IEEE 802.1d standard for the MAC layer. It aims to prevent the occurrence of double frames in a switched Ethernet network. The double frames occur as a result of two or more parallel connections between the switches. Frames that occur multiple times in receivers can lead to malfunctions. Spanning Tree spans the physical network to a logical tree, in which only one path exists to the target. The switches or bridges communicate in a network using BPDUs (Bridge Protocol Data Unit). These configuration packets are sent to the MAC address 01-80-C2-00-00-10 as multicast frames. These frames are sent to the next lowest station (bridge or switch) every two seconds. In this way, parallel paths are detected and the best route is determined. There is then discussion of priorities or path costs, which take into account the data rate and distance. Ports with non-preferred paths are then deactivated. If the preferred path fails, the BDPU frame also stays out, which leads to a reorganization of the network. For complex nesting, the tree (Spanning Tree) is recalculated, which can lead to a delay of up to 30 seconds or more. Only then can the transfer be continued on the redundant path.

Subnet mask

The subnet mask specifies which part of the IP address is used as the subnet address. Example: in a Class A network (subnet mask 255.0.0.0), the first field of the IP address is the subnetwork. The IP address is 207.142.2.1, which means the subnet address is 207.0.0.0 and the device address is 142.2.1.

Subslot

A subslot describes the structure of the components or functions, such as hardware modules or logical units, within a slot.

Switch

A switch is a networking component that usually only routes Ethernet data packets to the ports where the target device is registered. Address evaluation is carried out on Layer 2 of the OSI model. Switches increase the data throughput and simplify the structure of various topologies.

TCP (Transmission Control Protocol)

The Transmission Control Protocol (TCP) or transmission monitoring protocol is an agreement regarding how data is to be exchanged between computers. All operating systems of modern computers master TCP and use it to exchange data with other computers. The protocol is a reliable, connection-oriented transport protocol in computer networks. It is part of the Internet protocol range, the basis of the Internet.

Unlike the Unified User Datagram Protocol (UDP), TCP creates a virtual channel between two endpoints of a network connection (sockets). Data can be transmitted in both directions within this channel. In most cases, TCP is based on the Internet protocol, which is why the TCP/IP protocol is often used. It is located in Layer 4 of the OSI model.

TCP/IP (Transmission Control Protocol/Internet Protocol)

The Transmission Control Protocol (TCP/IP) is a network protocol and, because of its great importance for the Internet, is also referred to simply as the Internet protocol. The structure of the protocol and integration into the OSI model are described in the TCP/IP reference model. Identification of the computer is via an IP address.

TCP/IP reference model

In order to structure communication tasks, functional layers, or layers, are differentiated in networks. The TCP/IP reference model is therefore vital to the Internet protocol family. It describes the structure and interaction of the network protocols from the Internet protocol family and divides them into four successive layers:

TCP/IP layer	OSI layer	Example
Application Layer	5 ... 7	HTTP, FTP, SMTP
Transport Layer	4	TCP, UDP
Network Layer	3	IPv4,IPv6
Network Layer	1 ... 2	Ethernet, Token Ring, FDDI

TFTP (Trivial File Transfer Protocol)

The Trivial File Transfer Protocol (TFTP) is ideal for transferring entire files. In doing so, it uses only minimal commands and the UDP unlinked protocol as a transmission medium.

UDP (User Datagram Protocol)

The User Datagram Protocol (UDP) is a minimal, wireless network protocol that is part of the transport layer of the Internet protocol family. The UDP transfers data over the Internet to the correct application, without backing up the data transfer.

Web server function

Device interface for configuring and diagnosing with a standard browser (device homepage).

XML (Extensible Markup Language)

The Extensible Markup Language (XML) is a markup language for displaying hierarchically structured data in the form of text files. XML is preferably used for data exchange between different IT systems. An XML document consists of text characters, the simplest case being ASCII, and it can therefore be read by a human. By definition it does not contain binary data.

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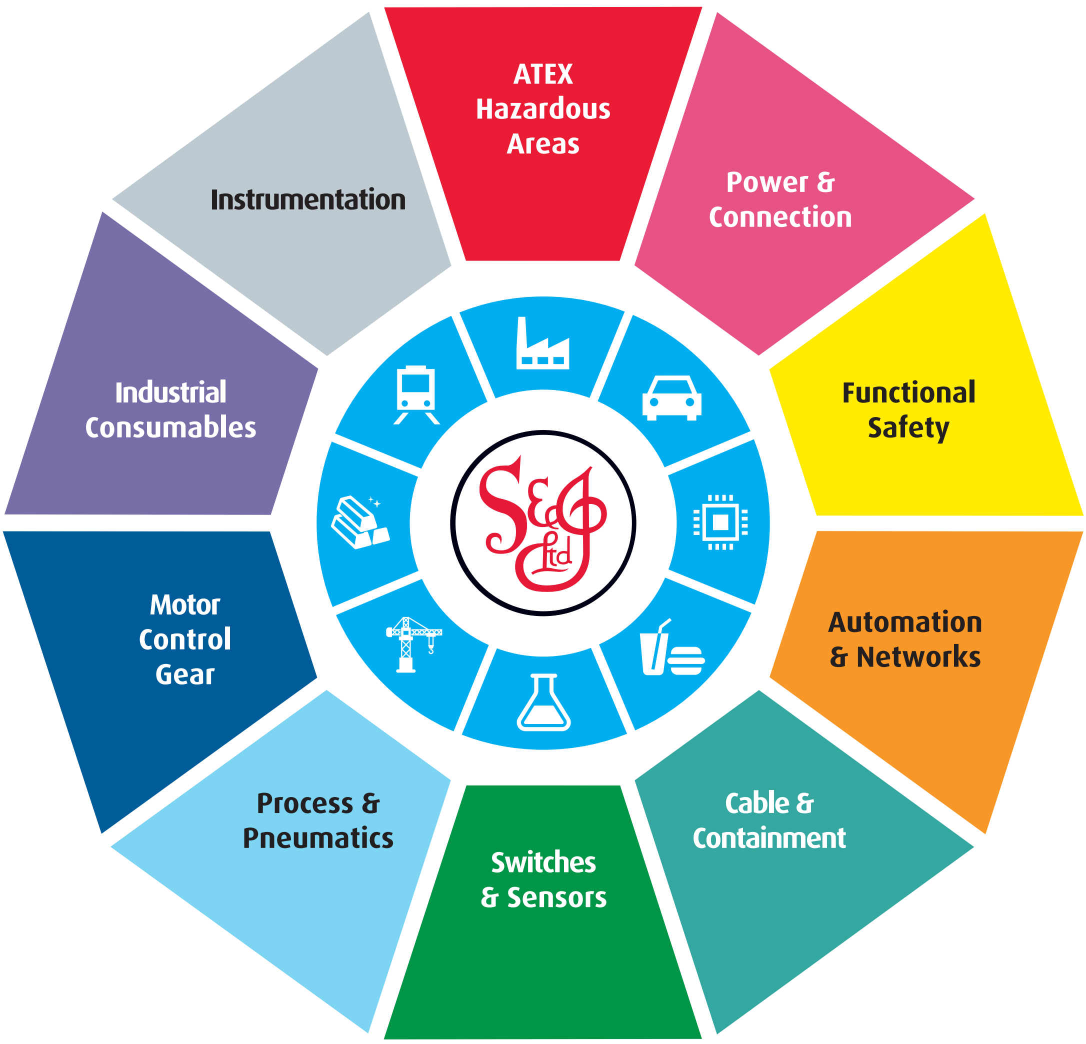

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