PROFINET
Safety for the future

Products
Diagnosis
Monitoring
Training
Consulting
Content

Basics .......................................................................................................................... 4

Standards and guidelines ....................................................................................... 5

PROFINET Design Guideline and Commissioning Guideline ......................... 5

Parameters for network planning ........................................................................... 6

PROnetplan network planning software ............................................................... 8

ETHERtest V5.0/V5.1 and PROlinetest line tester ................................................. 10

PROscan® Active acceptance test and validation software .............................. 11

PROFINET-INspektor® NT analysis and diagnostic tool ................................. 14

PNMA II measuring point .................................................................................... 17

PROFINET DiagnosticDUO (PROscan® Active & PROFINET-INspektor® NT) 18

PROFINET Diagnostic set ..................................................................................... 19

PROmanage® NT network monitoring software .................................................. 20

Configuration example (permanent network monitoring) ................................ 22

PROFINET services ............................................................................................... 23

Products and services .......................................................................................... 24
PROFINET is a universal, Ethernet-based communication network that can be used in all areas of automation technology. Speedy vertical and horizontal data exchange across all levels – including the corporate control level – is the foundation for successful systems concepts.

Like PROFIBUS, PROFINET distinguishes between cyclical and acyclical data communication and additionally supports fast I/O communication (RT – Real Time and IRT – Isochronous Real Time). This is done while retaining the familiar design with a cyclical transfer of peripheral data between the field devices (I/O devices) and the process image in the I/O controller. This results in a high degree of flexibility because update rates are scalable (see Fig. 2).

Data in PROFINET networks is highly varied. Besides prioritized, cyclical PROFINET I/O data, acyclical data (e.g. TCP/IP, diagnostic messages or SNMP requests) can be transmitted (see Fig. 3).

Network topologies in PROFINET derive from the requirements of the systems to be networked. The most common structures are star, line, tree and ring-shaped. In practice, systems usually are a mix of the above structures. They can be implemented either with copper or fiber-optic cables.
Standards and guidelines

Measurement, planning, acceptance inspection and commissioning in PROFINET, and therefore the criteria for quality evaluation, are based on observing the following standards and guidelines as well as the experience of Indu-Sol GmbH.

- PI PROFINET Assembly Guideline – (V 1.0) Jan 2009
- EN 50173 / ISO IEC 11801 – Structured cabling systems
- EN 50310 – Application of equipotential bonding and earthing in buildings with information technology equipment
- VDI / VDE Guideline 2184 – Reliable operation and maintenance of fieldbus systems

PROFINET Design Guideline and Commissioning Guideline

The extensive options for configuration and utilization of a network necessitate careful planning and practice-oriented commissioning of the system. The user organization PROFIBUS & PROFINET International (PI) has defined quality criteria for planning, acceptance and commissioning, as well as the metrological evaluation of a network in its latest Design and Commissioning Guideline. It is intended as a guideline for all persons and organizations involved in the planning, installation, operation and maintenance of such systems.

In the planning stage, network utilization should be considered in addition to structure. For this purpose, it is important to know the relationships between update rate, line depth and network structure. Practical planning tools like PROnetplan by Indu-Sol can be used to display such relationships in an interactive graphic to avoid weak spots.

Moreover, it is useful to define the requirements for IO devices in advance. The categorization in Conformance Classes (CC-A, CC-B, CC-C) is a useful aid to users when selecting devices that have no more than the required functionality. Requirements include simultaneous access to devices by several controllers (IO controllers), support for media redundancy, detection of topology information in the network, device exchange without repeated use of a parameterization device, as well as applications with very short cycle times and low variation.

The selection and placement of network components in the network structure depends on the performance of the devices. It is described by the net load classes (IO Security Level 1 – see the “standards and guidelines” box).

The years of experience with fieldbus technology have shown that the extensive diagnostic options of controllers in the area of device diagnostics should be expanded by an additional measurement to verify the quality of communication. The measurements serve as dual purpose, namely a description of the PROFINET network on the one hand and ensuring operational reliability on the other. Special attention should be paid to assuring the quality of the line connections (test when plant is stopped) as well as the transmission during operation.

RECOMMENDATION

In order to ensure reliable long-term functionality of the plant, measurements to verify compliance with the quality requirements (pages 7 and 16) are urgently recommended.
Parameters for network planning

Planning the network structure

The key properties of PROFINET are a variable network structure and the unlimited combinations provided by exploiting all topological shapes of the standard Ethernet. The topology results from the following criteria:

- Spatial arrangement of the components
- Distances to be bridged
- Requirements for the use of primary infrastructure / increased availability
- Consideration of netload (netload planning) and TCP/IP traffic
- Update rate in consideration of line depth
- Communication quality and telegram traffic
- Requirements for potential isolation/EMC

Selecting the right topology is important for the further planning of a PROFINET automation system. If required, the topology has to be adapted in a later inspection step.

Update time

The update rate is the interval at which the data between the controller and IO device is updated. It can be set individually for each device in the controller (standard setting: 2 ms). In addition to considering the requirements of the process, also consider the PLC cycle time. Indu-Sol recommends setting the update time for devices to at least half the PLC cycle time. The guiding principle is “Update only as necessary – not as much as possible.” The switching behavior of each device and the installed line depth, i.e. the number of passing devices (switches and IO devices with integrated switches) on the line, are critical for compliance with the update rate. An increasing number of passing devices prolongs the duration of the telegram. The variation of the real from the set update rate keeps increasing. It is called “jitter” and indicated in percent. Measurements to show compliance with update rates and devices of different netload classes are especially sensitive to peak loads demonstrating the network quality in consideration of utilization is especially important during the acceptance test or troubleshooting of a system.

Netload

The cyclical netload generated by each PROFINET device has a maximum in the connection between the controller and the first device. In order to permanently ensure the flawless functioning of the PROFINET network the following tolerances for planning and realization have to be ensured:

<table>
<thead>
<tr>
<th>Netload</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20%</td>
<td>No action required</td>
</tr>
<tr>
<td>20% ... 50%</td>
<td>Review of planned netload is recommended</td>
</tr>
<tr>
<td>&gt; 50%</td>
<td>Take action to reduce netload</td>
</tr>
</tbody>
</table>

It can be seen from the practical applications that the existing netload consists of both PROFINET and TCP/IP communication. Although the PROFINET communication is generally prioritized at switches (network nodes), TCP/IP communication may sometimes jump the queue. Whether and to what extent this happens – or can happen – can be seen from the load ratio (PROFINET to TCP/IP communication). Since different netloads (peak loads) affect the compliance with update rates and devices of different netload classes are especially sensitive to peak loads demonstrating the network quality in consideration of utilization is especially important during the acceptance test or troubleshooting of a system.

Sources:
PI Commissioning Guideline (V 1.36 / Dec. 14) pp. 104

TCP/IP telegrams

PROFINET telegrams

![Fig. 4: Illustration of telegram jitter](source)

![Abb. 5: TCP/IP devices are connected unfavorably → higher netload](source)

![Abb. 6: TCP/IP devices are connected optimally → low netload](source)
Line depth

Because in PROFINET (RT) it cannot be determined whether a device (switch) is operating in store-and-forward or in cut-through mode a delay has to be expected for every passing device.

This delay has to be considered when designing a network in the planning phase. Fundamentally, the maximum line depth depends on the update time and the switch mode (see the “line depth” tables). Indu-Sol recommends observing the values from the PI guideline “Line depth for store-and-forward switches”.

<table>
<thead>
<tr>
<th>Max. line depth for update time of</th>
<th>1ms</th>
<th>2ms</th>
<th>4ms</th>
<th>8ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>14</td>
<td>28</td>
<td>58</td>
<td></td>
</tr>
</tbody>
</table>

Access points

When planning PROFINET networks the guideline recommends passive access points for network diagnostics.

**Why?**
- During commissioning or maintenance, to analyze the network traffic or read out devices
- To connect diagnostic devices during running operation without interruption
- For troubleshooting or long-term diagnosis/preventative maintenance of the network condition

**How?**
- Using passive, feedback-free TAPs (e.g. PROFINET measuring point PNMA II - see page 17)
- Using a smart TAP (e.g. PROFINET-INspektor® NT – see page 14)

**Please note:**
In principle, an initial rough analysis of the network traffic (telegram analysis) is also possible via a mirror port on the switch using analysis software (e.g. Wireshark). However, this port only delivers 100 Mbps. But the cable carries incoming data to the controller at 100 Mbps on one wire pair and outgoing data from the controller at 100 Mbps on the other wire pair. Thus the port of the switch cannot diagnose more than one half of the data flow.

**RECOMMENDATION – Quality values**

<table>
<thead>
<tr>
<th>Recommendations on the quality values in PROFINET by Indu-Sol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jitter</strong></td>
</tr>
<tr>
<td><strong>Telegram gap</strong></td>
</tr>
<tr>
<td><strong>Error telegram</strong></td>
</tr>
<tr>
<td><strong>Load ratio</strong></td>
</tr>
<tr>
<td><strong>Netload</strong></td>
</tr>
</tbody>
</table>
**PROnetplan network planning software**

**PROnetplan** is a software for the preliminary planning of industrial networks. The network can be assembled intuitively on a graphic interface. Important parameters like the net load at the controller are calculated and displayed automatically based on the line depth and the preset update rate. With a simple simulation of the communication parameters or changes in the network structure, potential bottlenecks can be identified and eliminated during the planning stage. All devices and the predicted net load for each interface are listed in a clear overview. Free switch or device ports as well as the line depth are shown for each device. A special feature is the automated notification about the impact on net load when integrating components with TCP/IP communication. As in real hardware configuration the update rate can be set uniformly for all devices or separately for each device. Security pop-ups show the locations in a network where the use of a firewall would be advisable.

In addition to network optimization, the topology created with **PROnetplan** may serve both as a platform for discussion with the customer and as a document for network installation.

<table>
<thead>
<tr>
<th>Device type</th>
<th>Device name</th>
<th>Number of ports</th>
<th>Free ports</th>
<th>Netload (Byte)</th>
<th>Netload generated (%)</th>
<th>Local netload (%)</th>
<th>Allocated controller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controller</td>
<td>Controller 1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td>7,4</td>
</tr>
<tr>
<td>Switch</td>
<td>Switch 1</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td></td>
<td></td>
<td>7,4</td>
</tr>
<tr>
<td>Switch</td>
<td>Switch 2</td>
<td>8</td>
<td>6</td>
<td>0</td>
<td></td>
<td></td>
<td>2,56</td>
</tr>
<tr>
<td>Switch</td>
<td>Switch 3</td>
<td>8</td>
<td>5</td>
<td>0</td>
<td></td>
<td></td>
<td>4,84</td>
</tr>
<tr>
<td>Uplink</td>
<td>Uplink 1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IO Device</td>
<td>IO Device 1</td>
<td>2</td>
<td>0</td>
<td>56</td>
<td>0,64</td>
<td>2,56</td>
<td>Controller 1</td>
</tr>
<tr>
<td>IO Device</td>
<td>IO Device 2</td>
<td>2</td>
<td>0</td>
<td>56</td>
<td>0,64</td>
<td>1,92</td>
<td>Controller 1</td>
</tr>
<tr>
<td>IO Device</td>
<td>IO Device 3</td>
<td>2</td>
<td>0</td>
<td>56</td>
<td>0,64</td>
<td>1,28</td>
<td>Controller 1</td>
</tr>
<tr>
<td>Switch</td>
<td>Switch 4</td>
<td>8</td>
<td>6</td>
<td>0</td>
<td></td>
<td></td>
<td>1,92</td>
</tr>
<tr>
<td>IO Device</td>
<td>IO Device 5</td>
<td>2</td>
<td>0</td>
<td>56</td>
<td>0,64</td>
<td>1,92</td>
<td>Controller 1</td>
</tr>
<tr>
<td>IO Device</td>
<td>IO Device 6</td>
<td>2</td>
<td>0</td>
<td>56</td>
<td>0,64</td>
<td>1,28</td>
<td>Controller 1</td>
</tr>
<tr>
<td>Switch</td>
<td>Switch 5</td>
<td>8</td>
<td>6</td>
<td>0</td>
<td></td>
<td></td>
<td>2,92</td>
</tr>
<tr>
<td>IO Device</td>
<td>IO Device 8</td>
<td>2</td>
<td>0</td>
<td>56</td>
<td>0,64</td>
<td>2,92</td>
<td>Controller 1</td>
</tr>
<tr>
<td>IO Device</td>
<td>IO Device 9</td>
<td>2</td>
<td>0</td>
<td>56</td>
<td>0,64</td>
<td>2,28</td>
<td>Controller 1</td>
</tr>
<tr>
<td>IO Device</td>
<td>IO Device 4</td>
<td>2</td>
<td>1</td>
<td>56</td>
<td>0,64</td>
<td>0,64</td>
<td>Controller 1</td>
</tr>
<tr>
<td>IO Device</td>
<td>IO Device 7</td>
<td>2</td>
<td>1</td>
<td>56</td>
<td>0,64</td>
<td>0,64</td>
<td>Controller 1</td>
</tr>
</tbody>
</table>

*Fig. 9: All devices are shown in a clear device list (including all relevant parameters)*
Automatically generated detail information:

**Netload**

PROnetplan dynamically shows the resulting load for every connection in the network. This also applies with complex network structures or networks with multiple controllers.

**Update time**

The update rate can be set uniformly for all devices or separately for each device.

**Line depth**

PROnetplan shows the line depth dynamically for each device. The communication partner can be assigned for every device in the network.

<table>
<thead>
<tr>
<th>Highlights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display of the netload for every connection in the network</td>
</tr>
<tr>
<td>Update rate setting</td>
</tr>
<tr>
<td>Indication of line depth for every device</td>
</tr>
<tr>
<td>Separate netload settings for each device</td>
</tr>
<tr>
<td>Definition of different network access devices, e.g. PROFINET-Inspektor NT or the PNMA II measuring point</td>
</tr>
<tr>
<td>Clear device list for all devices</td>
</tr>
<tr>
<td>Pop-ups with security information</td>
</tr>
<tr>
<td>Display of remaining free ports on switches and devices</td>
</tr>
<tr>
<td>Full-featured printer functionality</td>
</tr>
<tr>
<td>PDF export with numerous functions</td>
</tr>
</tbody>
</table>

**Network access**

All net access devices are shown in the software and can be considered in the planning phase.

**Free ports**

Displays remaining free ports on switches and devices.

**Payload**

For a more accurate calculation of the netload the real netload can be set for each device in the expanded view.

**Security information**

The user-friendly pop-ups with security information show immediately which devices have free ports that may need to be blocked and where the use of a firewall might be advisable.

**PROnetplan in conjunction with PROscan Active**

The topologies scanned with the PROscan Active analysis software (see page 11) can easily be fed into PROnetplan. This enables a comparison between the plan and reality. This procedure is very useful during an expansion or optimization of the network.
ETHERtest V5.0 / V5.1 and PROlinetest line tester

Certification and acceptance

The ETHERtest V5.0 line provides for all measurements required for the acceptance and certification of network cables up to Class Fx/Category 6a (1000 MHz). Not only line length but also attenuation, resistance, crosstalk (NEXT), delays, shielding and the proper contacts (connection schematic) are measured and evaluated. Beyond the certification of copper cables, attenuation and OTDR can be measured for single and multi-mode fiber optic cables by means of additional adapters (ETHERtest V5.1).

All recorded values are displayed graphically, which enables the error sources to be identified and localized with an accuracy of 10 centimeters. All measurements are stored automatically in the device and can be retrieved as measurement report using PC software.

Verification and troubleshooting

PROlinetest is an indispensable tool for all those who install or troubleshoot PROFINET systems. The device detects any wiring errors and tests the wires and wire pairs for continuity, breaks, short-circuits, cross-wiring and exceeded maximum cable lengths.

The measurement of the total cable length and the distance to the error location significantly simplifies troubleshooting. The adapter can also be used to check Drive-Cliq and M12 cable systems.

RECOMMENDATIONS – Line lengths and attenuation

Compliance with the limit values acc. to Cat. 5e/Class D+ is monitored for a maximum length of 100 m, i.e. 24 dB attenuation. This means that with a shorter cable (e.g. 10 m) compliance is monitored only for the maximum attenuation of 24 dB.

Weak spots are therefore not detected early. For this reason, all measurement results for attenuation and crosstalk should be evaluated against the cable length using the following tables.

<table>
<thead>
<tr>
<th>Cable length</th>
<th>Max. attenuation acc. to standard Cat. 5e for 100 MHz</th>
<th>Length-dependent max. attenuation, Indu-Sol GmbH</th>
<th>Length-dependent recommended max. attenuation by Indu-Sol GmbH</th>
</tr>
</thead>
<tbody>
<tr>
<td>100,0 m</td>
<td>24 dB</td>
<td>24 dB</td>
<td>21 dB</td>
</tr>
<tr>
<td>50,0 m</td>
<td>24 dB</td>
<td>21 dB</td>
<td>18 dB</td>
</tr>
<tr>
<td>25,0 m</td>
<td>24 dB</td>
<td>18 dB</td>
<td>15 dB</td>
</tr>
<tr>
<td>12,0 m</td>
<td>24 dB</td>
<td>15 dB</td>
<td>12 dB</td>
</tr>
<tr>
<td>6,0 m</td>
<td>24 dB</td>
<td>12 dB</td>
<td>9 dB</td>
</tr>
<tr>
<td>3,0 m</td>
<td>24 dB</td>
<td>9 dB</td>
<td>6 dB</td>
</tr>
<tr>
<td>1,5 m</td>
<td>24 dB</td>
<td>6 dB</td>
<td>3 dB</td>
</tr>
</tbody>
</table>

The qualitative evaluation of attenuation should be performed in consideration of line length.
Online analysis / topology scan

With the PROscan® Active software you can generate a detailed description of your PROFINET networks online during running production at any time. Thanks to PROFINET devices’ integrated LLDP protocol (detection of neighborhood relationships) it is possible to generate a complete topology map including all designations and connections in an extremely short time, and thereby simultaneously perform an initial simple diagnosis (line interruptions, device failures etc.) during operation. Other strengths of this product include flexible options for integration into existing plants and a simple, intuitive user interface.

The software helps to efficiently organize a complex network and, if required, perform necessary maintenance in a timely and direct manner. Its low resource requirements enable PROscan® Active to be installed on any commonly available touch panel.

![Fig. 12: PROscan® Active – clear visualization of the network topology](image-url)
**Device list**

In addition to the device information (manufacturer, ordering details), the automatically generated device list also gives a quick overview of the hardware and firmware versions of all devices used, allocating the device names, IP and MAC addresses accordingly. The evaluation of this data can be exported into an acceptance-relevant report at the push of a button.

**Port overview**

In addition to the device list with all device-relevant data, a list of port relevant data for each device is also available. The overview shows both the line lengths of copper and polymer fiber connections as well as the attenuation reserve of polymer fiber connections.

---

### Device list

<table>
<thead>
<tr>
<th>Device type</th>
<th>IP addresses</th>
<th>Subnet</th>
<th>Gateway</th>
<th>MAC address</th>
<th>Device name</th>
<th>HW version</th>
<th>SW version</th>
<th>Order number</th>
<th>Vendor ID</th>
<th>Device ID</th>
<th>Controller</th>
<th>RealTime Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>172.20.1.51</td>
<td>255.255.255.0</td>
<td>172.20.1.51</td>
<td>00:18:18:72:89:59</td>
<td>4209-cu-zeile4</td>
<td>6</td>
<td>V4.5.0</td>
<td>SCALANCE X-200</td>
<td>6GK5 208-0BA10-2AA3</td>
<td>42</td>
<td>2561</td>
<td>controller-table</td>
<td>RTClass2</td>
</tr>
<tr>
<td>172.20.1.54</td>
<td>255.255.255.0</td>
<td>172.20.1.54</td>
<td>00:48:08:26:79</td>
<td>phanos-switch-zeile3</td>
<td>5</td>
<td>V3.80.0</td>
<td>FL SWITCH SIMS ETH/FX</td>
<td>289103</td>
<td>176</td>
<td>78</td>
<td>controller-table</td>
<td>RTClass2</td>
</tr>
<tr>
<td>172.20.1.55</td>
<td>255.255.255.0</td>
<td>172.20.1.55</td>
<td>00:18:18:34:5A:6A</td>
<td>AO22-pof-zeile2</td>
<td>5</td>
<td>V5.0.22</td>
<td>SCALANCE X-200</td>
<td>6GK5 202-2B60-2BA3</td>
<td>42</td>
<td>2561</td>
<td>controller-table</td>
<td>RTClass2</td>
</tr>
<tr>
<td>172.20.1.56</td>
<td>255.255.255.0</td>
<td>172.20.1.56</td>
<td>00:18:18:1E:21:21</td>
<td>4209-pf-pof-zeile3</td>
<td>2</td>
<td>V7.0.1</td>
<td>M151-3</td>
<td>EES7 151-3B202-0BA3</td>
<td>42</td>
<td>769</td>
<td>controller-table</td>
<td>RTClass2</td>
</tr>
<tr>
<td>172.20.1.58</td>
<td>255.255.255.0</td>
<td>172.20.1.58</td>
<td>00:8C:07:63:32</td>
<td>4209-cu-zeile1</td>
<td>4</td>
<td>V4.5.1</td>
<td>SCALANCE X-200</td>
<td>6GK5 208-0BA10-2AA3</td>
<td>42</td>
<td>2561</td>
<td>controller-table</td>
<td>RTClass2</td>
</tr>
<tr>
<td>172.20.1.59</td>
<td>255.255.255.0</td>
<td>172.20.1.59</td>
<td>00:18:18:24:58</td>
<td>4200m-pf-zeile1</td>
<td>2</td>
<td>V4.0.0</td>
<td>M151-4</td>
<td>EES7 153-4A01-0B03</td>
<td>42</td>
<td>770</td>
<td>controller-table</td>
<td>RTClass2</td>
</tr>
<tr>
<td>172.20.1.60</td>
<td>255.255.255.0</td>
<td>172.20.1.60</td>
<td>00:18:18:1A:76</td>
<td>4209-cu-zeile2</td>
<td>4</td>
<td>V4.5.1</td>
<td>SCALANCE X-200</td>
<td>6GK5 208-0BA10-2AA3</td>
<td>42</td>
<td>2561</td>
<td>controller-table</td>
<td>RTClass2</td>
</tr>
<tr>
<td>172.20.1.64</td>
<td>255.255.255.0</td>
<td>0.0.0.0</td>
<td>00:63:66:54:63</td>
<td>copper-zeile7</td>
<td>130</td>
<td>V4.2.3</td>
<td>Hirschmann OCTOPUS</td>
<td>6GK5 208-0BA10-2AA3</td>
<td>42</td>
<td>2561</td>
<td>controller-table</td>
<td>RTClass2</td>
</tr>
<tr>
<td>172.20.1.66</td>
<td>255.255.255.0</td>
<td>172.20.1.66</td>
<td>00:18:17:30:7F:41</td>
<td>phanos-pf-zeile6</td>
<td>2</td>
<td>V2.0.0</td>
<td>ASI</td>
<td>BMU193</td>
<td>238</td>
<td>1912</td>
<td>controller-table</td>
<td>RTClass2</td>
</tr>
<tr>
<td>172.20.1.70</td>
<td>255.255.255.0</td>
<td>172.20.1.70</td>
<td>00:05:30:30:47</td>
<td>nun-mv-kc0406</td>
<td>1</td>
<td>V3.1.0</td>
<td>MIV Pro/Net</td>
<td>5528</td>
<td>328</td>
<td>289</td>
<td>controller-table</td>
<td>RTClass2</td>
</tr>
<tr>
<td>172.20.1.71</td>
<td>255.255.255.0</td>
<td>172.20.1.71</td>
<td>00:05:30:30:8D</td>
<td>mva-101x</td>
<td>100</td>
<td>V4.0.0</td>
<td>MIV M-Pro/device switch</td>
<td>054A-000510-0030</td>
<td>352</td>
<td>94</td>
<td>controller-table</td>
<td>RTClass2</td>
</tr>
<tr>
<td>172.20.1.74</td>
<td>255.255.255.0</td>
<td>172.20.1.74</td>
<td>00:21:19:09:7F</td>
<td>M151-3</td>
<td>EES7 153-4A01-0B03</td>
<td>42</td>
<td>770</td>
<td>controller-table</td>
<td>RTClass2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>172.20.1.75</td>
<td>255.255.255.0</td>
<td>172.20.1.75</td>
<td>00:05:30:2F</td>
<td>4209-pf-zeile1</td>
<td>1</td>
<td>V3.1.0</td>
<td>MIV Pro/Net</td>
<td>5528</td>
<td>353</td>
<td>289</td>
<td>controller-table</td>
<td>RTClass2</td>
</tr>
<tr>
<td>172.20.1.80</td>
<td>255.255.255.0</td>
<td>0.0.0.0</td>
<td>00:06:71:26:00:7A</td>
<td>pt-prozepktor-v1</td>
<td>273</td>
<td>256</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>172.20.1.81</td>
<td>00:06:71:20:00:37</td>
<td>PB-Inspektor V2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>172.20.1.82</td>
<td>00:16:77:20:28:0C</td>
<td>ASI-Prozeptor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Information on defective or rejected telegram packets (CRC error or discards) is important for detecting weaknesses and to perform an error analysis.
Explanations (Discards/Error telegrams)

Data packets may be discarded by the switch, e.g. because of malfunctions, transmission errors or queue overflow at the switches.

**PROscan® Active** determines the number of such discards (see Fig. 13) and the number of defective telegrams (CRC errors) from the devices and displays them in a table. This provides clues as to potential causes of error.

During the analysis of such information special attention needs to be paid to devices in communication lines with high load.

![Diagram of PROscan® Active](image)

**Checking the system reserve for optical cabling**

If using polymer optical fiber (POF), the optical system reserve (power budget) of every single connection can be determined in online operation. It is a measure for the available optical power reserve between transmitter and receiver to ensure trouble-free operation. It can be read out and displayed as a diagnostic value. If the attenuation reserve of a POF connection falls below 5 dB, it is immediately apparent where transmission problems might occur.

These are represented by an exclamation mark △ in the connection. This enables you to detect and remedy the weaknesses in your system at any time.

<table>
<thead>
<tr>
<th>System reserve</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 6 dB</td>
<td>The value is above the measurement range. No action required.</td>
</tr>
</tbody>
</table>
| > 2 dB to 6 dB | The value is within the valid measurement range. Trouble-free communication is ensured. Typical values for cabling without other plug-in connections:  
• 5 dB for cable lengths up to 30 m  
• 3,5 dB for cable lengths from 30 m to 40 m  
• 2,5 dB for cable lengths from 40 m to 50 m  
In case of deviation from the listed value ranges a cable inspection is recommended (check for additional plug-in connections, attenuation check). |

Source: PI Commissioning Guideline (V 1.36 / Dec. 14) pp. 88/89
The **PROFINET-INspektor® NT** is an intelligent, passive measurement and diagnostic tool for temporary or permanent monitoring of PROFINET networks. Due to its passive and feedback-free behavior it is highly suitable for online analysis.

The **PROFINET-INspektor® NT** is both a full-featured measuring device for network acceptance and a tool for condition monitoring.

### Highlights

- Display that shows errors directly
- Netload display with millisecond accuracy
- Alarms in case of unknown devices
- Choice of active or passive network diagnostics
- Network anomaly detection
- Seamless monitoring even for high network loads

### Network parameters – Quality parameters

All subsequently listed quality parameters are detected as events, evaluated, cached and displayed in a clear overview.

- Network load
- Telegram jitter
- Load ratio (broadcast and multicast net loads)
- Update times
- Device diagnoses
- Device failures
- Telegram gaps
- Error telegrams
- Telegram overtakes

---

**Fig. 15:** Clear, detailed device overview with selection of each network parameter
Device information

<table>
<thead>
<tr>
<th>MAC address</th>
<th>Last minute</th>
<th>History</th>
</tr>
</thead>
<tbody>
<tr>
<td>00-04-80-38-77-63</td>
<td>10.145.6.6</td>
<td>10.145.6.6</td>
</tr>
</tbody>
</table>

**IP address**: 100.145.6.6

**Name**: Netload

**Vendor**: PROFINET-INspektor® NT

**Device ID**: 0

**Device info**

**Alert (low priority)**: 0

**Alert (high priority)**: 0

**Failures**: 0

**Telegram gap**: 2,048

**Telegram overraddes**: 0

**Netload visualization (see Fig. 16)**

While other diagnostic devices determine the network load by the second or even the minute, the PROFINET-INspektor® NT measures netload by the millisecond and displays it. This makes even minimal load changes in a network detectable. Even in the millisecond range peak loads may cause significant disturbances in the network which would not be detectable without this analysis.

Such short-term peak loads may be caused, e.g. by erroneous hardware settings or active diagnostic tools that continuously send queries into the network.

The network should always be monitored for a consistent netload and any sources of disturbances should be removed. Continuous, passive analysis as provided by the PROFINET-INspektors® NT is an indispensable prerequisite.

**Please note:**

According to the current certification guideline PROFINET devices are tested and specified with a maximum load per millisecond between 1 and 10%, depending on the netload class.

**Source**: PROFINET IO Security Level 1 (Netload) – Version 1.2 – June 2015
Trigger function – Alarms

Trigger functions enable the setting of quality parameters for the network as a whole, but also individually for each device if required.

In the event of changes that exceed the preset thresholds alarm messages (SNMP, email, web interface) are sent or displayed directly via a potential-free contact.

The PROFINET-INspektor® NT has an integrated web server and a freely selectable IP address. This enables a visualization of the network condition by means of an Internet browser on any PC, on site or remotely.

In addition to each alarm message telegram copies are stored on the INspektor® and can be downloaded via the web interface for a more detailed error evaluation.

User-friendly display of network conditions with traffic light colors and time graphs enable any user to respond quickly in an emergency and ensure a good general overview.
The **PNMA II** provides feedback-free access for telegram recording in the PROFINET and other Ethernet-based networks during running production. We recommend installing the **PNMA II** measuring point permanently in the network connection between the automation device (controller) and the first switch, because the major part of the communication typically passes through here.

**Function**

For the feedback-free connection of an analysis tool (e.g. PROFINET-INspektor® NT or laptop) two monitor sockets (M1 and M2) are available on the **PNMA II** for diagnostics. This means both communication directions can be monitored simultaneously.

An analysis tool is connected to the monitor sockets by means of two network cables. For analysis and evaluation of the measurement results the telegrams from both communication directions can be overlaid. The **PNMA II** does not discard error telegrams. Instead, it forwards them.

**Highlights**

- If connecting a PROFINET-INspektor® NT via a PNMA II, only two additional patch cables are needed (no crossover cable required).
- In case of a power supply failure the PROFINET communication via the PNMA II remains intact.
- Power supply of additional analytic tools via the UOUT (24VDC) connector

**Properties**

- Monitoring of all protocols
- Supports all packet sizes
- No packet loss
- All connection ports on the front panel
- No additional effort to connect a measuring device
- Tested interaction with the PROFINET-INspektor® NT
- No free switch port necessary
- Bi-directional data transmission up to 100 Mbps
- No network interruption when connecting diagnostic tools

---

**Fig. 19: Integration of the PNMA II measuring point in the PROFINET network**
Combined, the PROscan® Active software and the passive data collector PROFINET-INspektor® NT form the perfect navigation system for your network: the PROFINET DiagnosticDUO.

Thanks to the teamwork between a live topology map and a diagnostic display the position of each device can be found immediately and its “health status” can be assessed. This enables you to respond promptly and directly to any irregularities.

Intuitive traffic-light colors provide a network analysis at a glance.

Highlights

- First user-friendly topological visualization of in-depth network analysis
- Continuous analysis of the communication quality (network load, telegram gaps, jitter etc.)
- Device status is indicated graphically with traffic-light colors in the topology
- Retrieval of current device list (PROFINET name, IP/MAC address, hardware/software versions, device types etc.)

IO link diagnostics

In addition to the PROFINET diagnostics IO link diagnostics become available for the first time. The transition from PROFINET to the IO link is displayed as well as a port overview where IO link device are connected.
Teamwork – PROFINET DiagnosticDUO

Both tools can be joined together by activating the function “Read out PROFINET-INspektor® NT” in the PROscan® Active software. This gives you a navigation system for your PROFINET network so you can see the status of all devices displayed graphically with traffic-light colors in the topology.

Fig. 21: Information from the topology with PROscan® Active in conjunction with the evaluated quality parameters of the PROFINET-INspektor® NT

---

**PROFINET Diagnostic set**

On request we will provide you with an instruction to the functions, benefits and uses of the complete contents of the PROFINET Diagnostic set (see page 25). This introduction is especially suitable for those in charge of commissioning, service and maintenance.

We will gladly provide a separate offer for individual devices (see page 24 ff.).

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**Highlights**

- Online network diagnostics: PROFINET-INspektor® NT
- Topology software: PROscan® Active
- Network monitoring software: PROmanage® NT
- Leakage current measuring clamp: EMCheck® LSMZ I
- Cable diagnostics: PROlinetest or alternatively\n  ETHERtest V5.0 or V5.1
For preventative, condition-oriented maintenance of PROFINET networks Indu-Sol has developed a strategy for permanent network monitoring (referred to as PNM in the following). It provides for condition monitoring with the goal of “warning before failure”.

The concept of PNM provides for a continuous network analysis with a decentral, passive data collector, the PROFINET-INspektor® NT. Whenever preset threshold values are exceeded this event is stored together with a time stamp. The installation is between the controller and the first switch port. Each controller therefore requires an INspektor®. With PROmanage® NT all external INspektors® are integrated in the monitoring via the existing Ethernet network, and the network conditions are bundled centrally on a server. The network-specific events are pre-processed by the PROFINET-INspektor® NT and provided chronologically by the PROmanage® NT network monitoring software for further processing and evaluation.

PROmanage® NT enables the evaluation, analysis and long-term storage of condition data for your fieldbuses and other industrial networks. For this purpose PROmanage® NT retrieves the port statistics of manageable switches and the events of the decentral data collectors (INspektors®), evaluates them and displays them graphically.

This sophisticated method of analysis makes irregularities immediately apparent. When a value exceeds or falls below a configurable threshold value an alarm activates. The statistic function keeps data exact to the minute available up to one year. This means historical events can be opened up for viewing at any time for cause analysis, e.g. of sporadic failures.

To improve system availability the following targets are set for a PNM system:
- Continuous monitoring of real communication
- Complete monitoring and detection of causes of network weaknesses
- Automatic alarms when negative developments occur
- Central overview of all networks
Network history

How is my network?

The network history provides a quick and clear overview of:

- The current network status
- How long a network has run without error
- When the last error occurred (with time stamp)

Network condition graph

A user-friendly interface can be used to display and evaluate the information. The interface can be adapted to your unique needs and spread over several physical screens for better overview.

Various parameters of different devices such as device temperature and failures can be compared in a graph to detect links in the event of malfunction.

Event messages with time stamp

With the integrated threshold management threshold values can be defined for every network parameter. When a limit is reached an entry with a time stamp and event description is made automatically in the event list. Information about network errors can be retrieved from the event list with a mouse click.

Alarm management

Integrated alarm management enables automatic forwarding of device notifications. By selecting suitable information medium (email, message services, OPC, SNMP) all messages can be transmitted to the responsible persons in a timely fashion. This shortens notification paths and prevents undesired plant breakdowns.
PROFINET permanent network monitoring

Configuration example (PNM)

Guideance system network (Ethernet TCP/IP)

Control level

Process network (Ethernet)

Functional group level

Remote external
Remote Service
Maintenance and Service

WORLD WIDE WEB

Alarm (external)
"Failure network"
Maintenance / Services

Network analysis
Remote access via VPN

Client

Report (internal)
"Failure network"
Plant operator

SNMP Trap

PROmanage® NT - internal

PROmanage® NT - external

SNMP request

Report (internal)
"Failure network"
Plant operator

Plant operator

Remote external

Client

SNMP request

Alarm (external)
"Failure network"
Maintenance / Services

Remote access via VPN

WORLD WIDE WEB

Configuration example (PNM)
PROFINET services

Consulting

Services include:
Based on years of experience we offer expert consultation in all matters related to fieldbuses and industrial data communication at all stages from the concept to practical use. We support you during network planning, documentation and commissioning. This includes e.g. the drafting of delivery specifications or product requirement documents. Our service also includes assembly supervision and the final acceptance and certification of your network. We offer training for your operating personnel to familiarize employees with the network specifications of your system. We will gladly visit you for a “round table” and demonstrate the opportunities offered by our permanent network monitoring.

Measurement

Services include:
- Measurement of communication quality and creation of a measurement report
- Acceptance and certification of systems according to standards and PI guidelines
- Commissioning support
- Emergency support for troubleshooting
- Close-to-bus EMC evaluation / evaluation of equipotential bonding quality
- WLAN measurement incl. site survey

Training

Services include:
- Planning / installation / service
- Fundamentals of Ethernet / PROFINET / WLAN / EMC
- Practical network know-how (cables, plugs, structure, address assignment, commissioning etc.)
- Measurement devices / principles / methods / diagnostic options
- Practice (installation, telegram exchange, PNM, switch management, network security etc.)
- Certification of PROFINET installers
PROFINET products and services

Network planning

PROnetplan (see page 8)
Network planning software

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROnetplan</td>
<td>114010009</td>
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</table>

Analysis | Diagnostics | Measurement

ETHERtest V5.0/V5.1 (see page 10)
PROFINET Line tester (suitable for certification)

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETHERtest V5.0*</td>
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</tr>
<tr>
<td>ETHERtest V5.1 (extendable for FOC)*</td>
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</tr>
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</table>

PROlinetest (see page 10)
PROFINET Line tester

<table>
<thead>
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<th>Ordering Details</th>
<th>Art. No.</th>
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</thead>
<tbody>
<tr>
<td>PROlinetest*</td>
<td>112010010</td>
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</table>

PROscan® Active (see page 11)
Active acceptance test and validation software

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROscan® Active – 1x license (Basic license)</td>
<td>117000014</td>
</tr>
<tr>
<td>PROscan® Active – 5x license</td>
<td>117000018</td>
</tr>
<tr>
<td>PROscan® Active – 25x license</td>
<td>117000019</td>
</tr>
</tbody>
</table>

*All adapters for PROlinetest and ETHERtest V5.0/V5.1 on request.
**PROFINET INspektor® NT** (see page 14)
Analysis and diagnostic tool

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFINET-INspektor® NT</td>
<td>124030100</td>
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</table>

**PNMA II** (see page 17)
PROFINET measuring point

<table>
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<tr>
<th>Ordering Details</th>
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<tbody>
<tr>
<td>PNMA II</td>
<td>114090100</td>
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</tbody>
</table>

**PROFINET DiagnosticDUO** (see page 18)
PROscan® Active (1x license)
PROFINET-INspektor® NT

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFINET DiagnosticDUO</td>
<td>124030020</td>
</tr>
</tbody>
</table>

**PROFINET Diagnostic set** (see page 19)
All essential tools for commissioning and troubleshooting

- Analysis and diagnostic tool **PROFINET-INspektor® NT**
- Topology software **PROscan® Active**
- Network monitoring software **PROmanage® NT**
- Line tester **PROlinetest** (optionally incl. ETHERtest V5.0/V5.1)
- Leakage current measuring clamp **EmCheck® LSMZ I**

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFINET Diagnostic set (with PROlinetest)</td>
<td>114010020</td>
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<tr>
<td>PROFINET Diagnostic set (with ETHERtest V5.0)</td>
<td>114010030</td>
</tr>
<tr>
<td>PROFINET Diagnostic set (with ETHERtest V5.1)</td>
<td>114010040</td>
</tr>
</tbody>
</table>
PROFINET products and services

Network monitoring

**PROmanage® NT** (see page 20)
Network monitoring software

*The licence defines the maximum number of network ports or devices retrieved simultaneously. (Ethernet switch: number of network ports = number of licence ports, 1 PB-INspektor® = 8 ports, 1 PN-INspektor® = 16 ports)*

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PROmanage® NT</strong> (80 ports*)</td>
<td>117000032</td>
</tr>
<tr>
<td><strong>PROmanage® NT</strong> (320 ports*)</td>
<td>117000034</td>
</tr>
<tr>
<td><strong>PROmanage® NT</strong> (640 ports*)</td>
<td>117000036</td>
</tr>
</tbody>
</table>

EMC analysis | EMC diagnosis | EMC measurement

**EmCheck® LSMZ I**
Leakage current measuring clamp

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EmCheck® LSMZ I</td>
<td>122010005</td>
</tr>
<tr>
<td>Set of measuring clamps (LSMZ I and MWMZ II)</td>
<td>122010006</td>
</tr>
</tbody>
</table>

**EmCheck® MWMZ II**
Mesh resistance measuring clamp

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EmCheck® MWMZ II</strong></td>
<td>122010010</td>
</tr>
<tr>
<td>Set of measuring clamps (LSMZ I and MWMZ II)</td>
<td>122010006</td>
</tr>
</tbody>
</table>

Infrastructure components

**Switch**
PROFINET switch (Conformity class B)

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PROFINET switch</strong></td>
<td>112080005</td>
</tr>
</tbody>
</table>
Infrastructure components

PROFINET plugs
RJ45 / M12 Fast Connect

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFINET plug RJ45 (180°)</td>
<td>114030003</td>
</tr>
<tr>
<td>PROFINET plug RJ45 (90°)</td>
<td>114030004</td>
</tr>
<tr>
<td>PROFINET plug M12</td>
<td>114030002</td>
</tr>
</tbody>
</table>

PROFINET cable
Cat5 massive / flexible

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFINET cable Cat5 (type A - massive)</td>
<td>114050001</td>
</tr>
<tr>
<td>PROFINET cable Cat5 (type B - flexible)</td>
<td>114060001</td>
</tr>
</tbody>
</table>

Services (Measurement/Training)

Measurement / Troubleshooting (see page 23)
Network analysis / Certification, Troubleshooting

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network analysis/Certification</td>
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<tr>
<td>Troubleshooting</td>
<td>210030003</td>
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</table>

Training (see page 23)
PROFINET seminar (2 days)

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training PROFINET (2 days-Schmoelln)*</td>
<td>220030001</td>
</tr>
</tbody>
</table>

Training (see page 23)
PROFINET seminar (PI certified incl. test)

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
</tr>
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<tbody>
<tr>
<td>Certified PROFINET Installer (2,5 days-Schmoelln)*</td>
<td>220030007</td>
</tr>
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</table>

Training (see page 23)
PROFINET WLAN

<table>
<thead>
<tr>
<th>Ordering Details</th>
<th>Art. No.</th>
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</thead>
<tbody>
<tr>
<td>Training WLAN (2 days-Schmoelln)*</td>
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</tr>
</tbody>
</table>

*On-site training at your premises on request.