**PROFINET on 100% Ethernet**

### PROFINET is Ethernet

- Ethernet is an established standard in the IT world for fast data transfer (IEEE 802.3)
- PROFINET is always full duplex \(\rightarrow\) simultaneous communication in both directions
- PROFINET is always "switched Ethernet"
- The topology can be influenced network load

### For comparison: PROFIBUS

- One line of “cable” to which everyone is connected
- \(\Rightarrow\) Performance depends on the number of devices

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For comparison:

- **PROFINET**
  - 100 Mbps full duplex
  - Switches connected into a line
  - The topology can be influenced network load

- **PROFIBUS**
  - One line of “cable” to which everyone is connected
  - \(\Rightarrow\) Performance depends on the number of devices

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**PROFINET take full advantage of the possibilities offered by Ethernet**
Profinet Vs. Profibus

Profinet works on the same principle as Profibus. Except:

- Higher carrier frequency 100-600MHz (3-20MHz)
- 2-4 twisted pair cable
- Bandwidth 10-1000Mbps (0.184-12Mbps)
- Different cables can be used in the same application
- Maximum length 100m and with flexible cables 80m
### Industrial Ethernet/PROFINET:
For quick installation
- **RJ45 liittimet 2 x 2 and 4 x 2**

#### Stripping Tools!

<table>
<thead>
<tr>
<th>Stripping</th>
<th>Install RJ45</th>
<th>Install M12</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="https://youtu.be/XQjVYFMR8Mk" alt="Stripping RJ45" /></td>
<td><img src="https://youtu.be/9e4G5DPPXHM" alt="Install RJ45" /></td>
<td><img src="https://youtu.be/CSwDQptulds" alt="Install M12" /></td>
</tr>
</tbody>
</table>

- **M12 plugs** (using stripping tool)
  IE FC cables: 4 ja 8- wires

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Unrestricted © Siemens AG 2018
Installation and grounding
Installation and grounding
Profinet telegram – no TCP/IP frame – no roaming

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preamble</td>
<td>SFD (Start Frame Delimiter)</td>
<td>7 Byte</td>
</tr>
<tr>
<td></td>
<td>Destination-MAC-address</td>
<td>6 Byte</td>
</tr>
<tr>
<td></td>
<td>Source-MAC-address</td>
<td>6 Byte</td>
</tr>
<tr>
<td>VLAN-Tag</td>
<td>VLAN-ID/VLAN-Priority</td>
<td>4 Byte</td>
</tr>
<tr>
<td>Type</td>
<td></td>
<td>2 Byte</td>
</tr>
<tr>
<td>Frame ID</td>
<td></td>
<td>2 Byte</td>
</tr>
<tr>
<td>User data</td>
<td></td>
<td>40 - 1440 Byte</td>
</tr>
<tr>
<td>Status</td>
<td></td>
<td>4 Byte</td>
</tr>
<tr>
<td>FCS (Frame Check Sequence)</td>
<td></td>
<td>4 Byte</td>
</tr>
</tbody>
</table>

- VLAN-ID=0, VLAN-Priority=6
- Type=0x8892 (Identification PROFINET Real-Time-Frame)
PROFINET device configurations and topology in TIA Portal

**TIA Portal – PROFINET**

- PROFINET devices (including network products) are configured using the TIA Portal.
- These settings are transferred to the SIMATIC CPU and from there to the PROFINET devices.
- The CPU defines IP addresses and PN names according to the topology made in the TIA Portal. Also for network devices.
- In the topology, all devices must support the Profinet mechanism.

**PROFINET TIA in Portal**

All parameters relevant to PROFINET are defined in the TIA portal and then transferred to the SIMATIC CPU.
Topology definition allows automatic configuration

- **Topology editor (Classic STEP7)**
  - Define cabling

- **Topology editor (STEP7 – TIA Portal)**
  - Define cabling
Topology detection uses LLDP communication

1. I am "X208"
2. Port 1
   PartnerID:PortID: XXX
   Port 1: X208.P1
3. Topology query of STEP7
4. LLDP MIBs are reading
5. Topology editor

I am "CPU319-3PN/DP"

<table>
<thead>
<tr>
<th>Port</th>
<th>PartnerID:PortID</th>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port 1</td>
<td>CPU319-3PN/DP.P1</td>
<td>XXX</td>
</tr>
</tbody>
</table>
WITH PROFINET YOU ALWAYS HAVE USE MANAGERED SWITCHES!

Automatic configuration saves time and minimizes errors

With this function, the PROFINET IO controller automatically enters the IP address and device name of the PROFINET IO devices without a programming device (PG).

The requirements for automatic configuration are:
- The IO controller and IO devices must support the PROFINET function "Device replacement without exchangeable medium / PG".
- In STEP7, you must select the option "Replacing the device without removable media" – "Device replacement without exchangeable medium"
- The devices must be reset to factory settings – factory reset.
- **Profinet GSDxml device description must be found on all devices - including switches!**
- The configured topology must correspond to the actual topology!
Profinet network topologies

- **Star**
  (typically motor centers - Simocode)

- **Ring** - MRP

- **Tree**

- **Linear**
Response time in line topology – 14 stations (1.8 ms)
Siemens Profinet IO device with “cut through” switch – Ertec Asics circuit has been used for interface.

\[ T_t = \text{Transmission time of minimum frame} = \text{approximately 7} \mu s \]

\[ R_{tb} = \text{Run time of bit on the cable at 100 Mbps and 100 m cable between two nodes} > 0,5 \mu s \]

\[ T_{PT\text{switch}} = \text{Throughput time through a switch. For RT\_Class\_1 approximately 10 \mu s (in GSD file)} \]

Basic calculation:

<table>
<thead>
<tr>
<th>Length of minimum frame:</th>
<th>Including preamble and SFD:</th>
<th>Idle time:</th>
<th>Total:</th>
</tr>
</thead>
<tbody>
<tr>
<td>64 bytes including process data</td>
<td>08 bytes as header</td>
<td>12 bytes after each Ethernet frame</td>
<td>84 bytes</td>
</tr>
</tbody>
</table>

**RT Minimum/maximum transmission time without wait times**

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Tt [\mu s]</th>
<th>Nn (asemien määrä ketjussa)</th>
<th>Rtb [\mu s]</th>
<th>TPTswitch [\mu s]</th>
<th>Tt.min [ms]</th>
<th>Tt.max [ms]</th>
</tr>
</thead>
<tbody>
<tr>
<td>84</td>
<td>6.7</td>
<td>14</td>
<td>0.5</td>
<td>10</td>
<td>0.154</td>
<td>1.729</td>
</tr>
</tbody>
</table>

This calculation can only be used with Siemens devices. It has been found that some other manufacturers has used standard “store and forward” switches in device Profinet interface. These do not guarantee a stable response time.
Response time in line topology – 20 stations (2,6 ms)
Siemens Profinet IO device with “cut through” switch – Ertec Asics circuit has been used for interface.

\[ T_t = \text{Transmission time of minimum frame} = \text{approximately} 7 \mu s \]

\[ R_{tb} = \text{Run time of bit on the cable at 100 Mbps and 100 m cable between two nodes} > 0,5 \mu s \]

\[ T_{PT\text{switch}} = \text{Throughput time through a switch. For } RT\text{-Class}_1 \text{ approximately } 10 \mu s \text{ (in GSD file)} \]

Basic calculation:
- Length of minimum frame: 64 bytes including process data
- Including preamble and SFD: 08 bytes as header
- Idle time: 12 bytes after each Ethernet frame
- Total: 84 bytes

<table>
<thead>
<tr>
<th>Byte</th>
<th>( T_t ) [( \mu s )]</th>
<th>( N_n ) (asemien määrä ketjussa)</th>
<th>( R_{tb} ) [( \mu s )]</th>
<th>( T_{PT\text{switch}} ) [( \mu s )]</th>
<th>( T_{t_min} ) [ms]</th>
<th>( T_{t_max} ) [ms]</th>
</tr>
</thead>
<tbody>
<tr>
<td>84</td>
<td>6,7</td>
<td>20</td>
<td>0,5</td>
<td>10</td>
<td>0,217</td>
<td>2,527</td>
</tr>
</tbody>
</table>

This calculation can only be used with Siemens devices. It has been found that some other manufacturers has used standard “store and forward” switches in device Profinet interface. These do not guarantee a stable response time.
RT: Media Redundancy Protocol (MRP)  
1/2

MRP is a ring redundancy method used in Profinet applications. The redundancy manager sends test messages from each of its ring ports as long as the messages arrive at the other ring port. This way the manager knows that the ring is intact. At the same time, it prevents messages from circulating indefinitely in the ring, closing one of the ring ports.
When test messages no longer arrive at another ring port, such as a damaged cable, the manager opens the closed ring port. In this case, post-break subscribers are available. Network recovery (reconfiguration) takes up to 200 ms (50 subscribers).
IRT: MRPD seamless ring. Max. 32 devices

The MRPD mechanism is based on IRT and MRP. A reconfiguration time of 0ms is possible by sending cyclic IRT packets duplicated in both directions on the ring. The recipient receives the same IRT frame twice if there are no errors on the network.

The devices receive this information on both ring ports, so there is no ring remodeling time. As with MRP, redundancy management prevents loops.
Redundancy example
Segmented production network – PN/PN Coupler

Line Control

WinCC

Production OT network

CPU 1515R (primary)

CPU 1515R (backup)

CPU 1515R (primary)

CPU 1515R (backup)

IO device 1 (S2)

PN/PN Coupler (S2/S2)

IO device 2 (S2)
Web extension - Network topology - graphical view

### SIMATIC CONTROLLER - CPU319/CPU 319F-3 PN/DP

**Module Information**

<table>
<thead>
<tr>
<th>Slot</th>
<th>Module</th>
<th>Order number</th>
<th>I Address</th>
<th>O Address</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IM151-1 HF</td>
<td>16820-09400-0400</td>
<td>8000</td>
<td>8000</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>PME1024-48V</td>
<td>66821-04000-0000</td>
<td>3000</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4DI DC24</td>
<td>66822-04000-0000</td>
<td>3000</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4DI DC24</td>
<td>66822-04000-0000</td>
<td>3000</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>PML2100I</td>
<td>66822-04000-0000</td>
<td>3000</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>F-D16x18 DIGITAL</td>
<td>3901-00001-0000</td>
<td>1000</td>
<td>1000</td>
<td></td>
</tr>
</tbody>
</table>

**Status - Identification**

- **PID** 31 on PB system 1, Belt 3: Module removed: IM151-1
- **Module:** 4DI DC24 V 40 address: 1000
Online view on the TIA Portal.
Service bridge (Scalance XC200 series)
Sinetplan – Offline simulation for load in Profinet network

- Port-by-port simulation ✓
- Import of STEP7 & TIA Portal projects ✓
- Import of the configuration with AutomationML ✓
- Online scan function ✓
- Validation of the PROFINET planning guideline ✓
- Report function with detailed results ✓
Proneta (PROFINET network analyzer - free!)

Requirements

• Easy to set up devices and network without PLC “tools”
• Detects devices and topology automatically
• Address settings
• IO testing

Used to

• cabinet manufacture
• Commissioning

• www.siemens.com/proneta
SINEC PNI is a program that can be set for a network-specific parameter to SCALANCE and RUGGEDCOM devices.

The configuration can be performed simultaneously for multiple devices.

- Network Scanning of all PROFINET and RUGGEDCOM devices
- Initialization by setting the following parameters for the devices:
  - address, subnet and gateway
  - Initial password change (Scalance ja Ruggedcom)
  - name (PROFINET)
  - I&M information to identify the device (PROFINET)
  - SysName, sysContact and sysLocation
  - Activate DHCP-client
  - Resets to factory settings
  - Resets to the default PROFINET settings
  - ping
  - Flashes LEDs
  - Open Web Based Management
## SINEC PNI Product editions

<table>
<thead>
<tr>
<th>No licence</th>
<th>Only one License per copy</th>
<th>SINEC PNI Professional (03/2021)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SINEC PNI Basic (02/2020)</td>
<td>SINEC PNI Advanced (11/2020)</td>
<td></td>
</tr>
<tr>
<td><strong>Features</strong></td>
<td><strong>Features</strong></td>
<td><strong>Features</strong></td>
</tr>
<tr>
<td>- Step 1</td>
<td>- <strong>Only one License per copy</strong></td>
<td>- <strong>Only one License per copy</strong></td>
</tr>
<tr>
<td>- Scan network</td>
<td>- + Set Time</td>
<td>- + Generate SSL and SSH Keys</td>
</tr>
<tr>
<td>- Set IP, subnet, gateway</td>
<td>- + Set DNS Proxy</td>
<td>- + Set Hardening profile</td>
</tr>
<tr>
<td>- Set DHCP Client</td>
<td>- + Set Syslog-Client</td>
<td>- + Set NAT/ NAPT</td>
</tr>
<tr>
<td>- Set PROFINET / System name</td>
<td>- + Set NTP-Client</td>
<td>- + Set Firewall / ACLs</td>
</tr>
<tr>
<td>- Set I&amp;M Data</td>
<td>- + Set RADIUS-Client</td>
<td>- + Set SINEMA RC Client</td>
</tr>
<tr>
<td>- Reset to factory</td>
<td>- + Configure DHCP Server</td>
<td>- + Password protection</td>
</tr>
<tr>
<td>- Change Default Password</td>
<td>- + Set SSID</td>
<td></td>
</tr>
<tr>
<td>- Flash LED</td>
<td>- + Set WLAN Mode</td>
<td></td>
</tr>
<tr>
<td>- Ping</td>
<td>- + Set Country</td>
<td></td>
</tr>
<tr>
<td>- <strong>Step 2</strong></td>
<td>- + Set Channel</td>
<td></td>
</tr>
<tr>
<td>- Firmware Update</td>
<td>- + Set frequency</td>
<td></td>
</tr>
<tr>
<td>- Diagnostic Downloads (logs with config)</td>
<td>- + Set SSID Security</td>
<td></td>
</tr>
<tr>
<td>- Configuration copy (up/down)</td>
<td>- + Set static VLANs</td>
<td></td>
</tr>
<tr>
<td>- Set SNMP (V1, V2C, V3)</td>
<td>- + Set VLAN IP addresses</td>
<td></td>
</tr>
<tr>
<td><strong>Price</strong></td>
<td><strong>Price</strong></td>
<td><strong>Price</strong></td>
</tr>
<tr>
<td>Free of charge</td>
<td>xxx €</td>
<td>xxx €</td>
</tr>
</tbody>
</table>
The automation network is connected to the OT network, not directly to the IT network. ADVANTAGE: A more secure data transfer to the entire production line is achieved.

- The production cells are connected to each other with PN / PN Couplers
- Each cell is connected to the OT network with its own Firewall / VPN module
- VPN modules can be used to build a horizontal remote connection within the production line -> network monitoring and maintenance of the entire production line and, if necessary, a-cyclic data transfer between cells
- The devices on the OT network are managed and controlled centrally by Sinec NMS.
- Production network protected from IT network vulnerabilities -> trouble-free production
- The line control CPU is connected to an OT network or a separate network
Segmented production network (IEC62443)

Scalance S/SC VPN

WinCC

IT network

DMZ - area

Cloud PG

Sinec NMS

Sinema RC serveri

Production OT network

Production cell

Production cell

Production cell

Production cell
SINEC software family (NMS, PNI & INS)
Network levels (OT) – Factory automation
SCALANCE X managed switches
Layer 2 applications (Profinet)
Thank you for your interest!

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