PROFINET

Learning Outcomes (LO) of

Certified PROFINET IO Network Engineer (CPNE)

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Order No: 4.812

Revision Log

Identification	Version	Originator	Date	Change Note / History / Reason
TC1-WG9-05-0001	0.1.0	TC1 WG9 Training	06Jun05	Initial version
	0.2.0	TC1 WG9 Training	26Aug05	add financial aspects
	1.0.0	TC1 WG9 Training	01Dec08	Modify learning outcomes list. Modify syllabus. Modify course duration. Add troubleshooting to practical test. Other minor changes.
	1.0.1	TC1 WG9 Training	28Sep10	Add fast startup and white papers as references. Reformatting.
	1.0.2	TC1 WG9 Training	25 Jan 11	Replace IRT Top by RT_CLASS_3, add reference to IRT Wireshark capture and update complete references with the sources, open the possibility to make a shorter practical test.

Course Title: Certified PROFINET IO Network Engineer

Course Code: **CPNE**

Course Duration: **3 Days (2 Days + 0.5 day for examination)**

Grading Type: **Normal**

Prerequisite: Industrial Automation Background.

Developed by the Working Group “Training” (WG9) within the Technical Committee for “Test and Certification” (TC1).

This Learning Outcome is one of a series of several courses:

4.712 Certified PROFIBUS Engineer
4.722 Certified PROFIBUS Installer
4.732 Certified PROFIBUS-PA Engineer
4.812 Certified PROFINET IO Engineer
4.822 Certified PROFINET Installer

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1 Aims & Objectives

The objective of this course is to provide both hands-on and theoretical training on PROFINET IO. The course will provide an opportunity for the participant to acquire the required skills to design, set up, operate, diagnose and troubleshoot PROFINET IO networks.

2 Learning Outcomes

The following learning outcomes specify what candidates will know or be able to do as a result of successfully completing the course. These learning outcomes are developed during the course and assessed during the tests.

On successful completion of this course students will be able to:	**Assessment Mode**
Ethernet Basics	
Know what Ethernet is, including IEEE802.3, ISO/OSI model, TCP, UDP, IP, ARP, Ping, Ethernet frame, and baud rates	Theory Exam
Understand Network Addressing: MAC Address, IP Address, and Subnet Mask	Theory Exam
Network Infrastructure	
Understand Network Switches, hubs, routers, layer 3 switches, and firewalls	Theory Exam
Describe Switch features: Half/full duplex, auto crossover, auto negotiation, managed switches, cut through vs. store and forward	Theory Exam
List the switch features that are required for PROFINET	Theory Exam
Monitor Ethernet traffic with switch port mirroring or a network tap	Practical Exam
Understand using Ethernet Wireless with IEEE 802.11 for PROFINET	Theory Exam
Understand the different types of Network topology	Theory Exam
Understand what SNMP (Simple Network Management Protocol) is used for in PROFINET systems	Theory Exam
Understand how LLDP (Link Layer Discovery Protocol) is used for topology discovery and PNIO Device replacement	Theory Exam
Know the types of Cables and Connectors available for Ethernet and their pinouts.	Theory Exam
PROFINET IO	
Understand the PROFINET Device certification requirement	Theory Exam
Describe the roles of PROFINET IO Controller, IO Device, and IO Supervisor	Theory Exam
Understand RT (Real Time) Communications, its typical I/O cycle times, and how it is implemented in the stack	Theory Exam

Describe IRT (Isochronous Real Time) Communications, its typical I/O cycle times and jitter, how it is implemented in the stack, IRT communication time scheduling, clock synchronization: • IEEE 1588 V2 • Sync Master / Sync Slave communication • Transparent Switches, Device I/O frame time scheduling (RT_CLASS_3), and ASIC hardware requirements	Theory Exam
Know how Proxy functionality works	Theory Exam
Describe how PROFINET fits in the ISO/OSI model	Theory Exam
Describe the IO Device Slots/subslots model	Theory Exam
Understand Application Relations (AR's) and Communication Relations (CR's)	Theory Exam
Understand that the Standard channel (UDP/IP for configuration) and Real Time channel (for cyclic I/O and alarms)	Theory Exam
Be familiar with the PNIO Contoller/Device Startup Sequence (connect request, parameterization, cyclic I/O, fast startup)	Theory Exam
Understand how the four parameters Reduction ratio, send clock, frame send offset, phase are used for IO CRs	Theory Exam
Be familiar with the Read and Write record services (Parameterization, diagnostics, I&M functions, etc.)	Theory Exam
Understand the PROFINET model for Diagnostics (device, module, channel, network)	Theory Exam
Be familiar with the different Alarm types and priorities	Theory Exam
Understand the DCP – Discovery and Configuration Protocol and how it is used in the Engineering Tool and by the IO controller at startup	Theory Exam
PNIO Engineering	
Understand the role of a GSD file and be able to import it into the Hardware Config Tool	Class Exercise
Be able to Configure a PROFINET IO system	Practical Exam
Know how to set I/O cycle times	Class Exercise
Know how to integrate a fieldbus (PROFIBUS, Devicenet, etc.) with a proxy	Class Exercise
Know how to download PNIO device names	Practical Exam
PNIO Ethernet Frames	
Know the structure of Standard Ethernet frame and also VLAN Priority Tagging	Theory Exam
Understand the PN Real Time Ethertype and PN Frame ID's	Theory Exam
Be familiar with the structure of PROFINET RPC and Service PDUs	Theory Exam
Understand the different types of PROFINET frames: Connect Request and Response, Write Records for parameterization, End of Parameterization, Ready for Data Exchange, and Cyclic I/O frames.	Theory Exam
Know the structure of the I/O data, IOPS (Provider Status), and IOCS (Consumer Status) in the PNIO frame.	Theory Exam
Be familiar with the Cyclic I/O Watchdog Timeout	Theory Exam
Be familiar with Read and Write Record request and response frames	Theory Exam

Be familiar with Alarm Notification and Alarm Acknowledge frames	Theory Exam
Introducing Wireshark	
Know how to capture Ethernet frames	Practical Exam
Know how to set up PROFINET coloring rules	Class Exercise
Be able to Capture a PNIO Startup Sequence and examine the frames	Practical Exam
Be able to Capture an alarm and examine the frames	Class Exercise
Be able to use Wireshark to Troubleshoot typical startup problems	Practical Exam
IRT Calculations	
Be able to calculate the following for IRT communications: • Minimum Ethernet frame time • Time for minimum Ethernet frame from the IO Controller to the most remote IO Device • Time for all devices to receive I/O data from IO controller • Determine how many devices can be updated in a specific time	Theory Exam
Know the Maximum number of hops through switches considering jitter.	Theory Exam
Introducing PROFINET XML-Viewer	
Know the GSD file naming convention	Theory Exam
Understand the role of the Vendor ID and Device ID in file and how they are assigned	Theory Exam
Be familiar with the Browser view and XML view	Class Exercise
Be able to examine the contents of the GSD file for DAP's, Modules, Parameters, Value Lists, Channel Diagnostics text, Icon Bitmap file, Module Categories, Multiple Language support	Class Exercise

3 Instructors

The instructor(s) must have passed the Certified PROFINET Network Engineer Course as a minimum and must be registered with PI.

4 Training and assessment methods

The training should cover the topics listed in the syllabus below and must cover the required learning outcomes. An example slide-set in English is provided by PI as a guideline. The delivery may be customized and formatted to suit the desires of the instructor and the needs of the candidates. The training must include a significant practical element in which the candidates can apply the theory concepts by testing a small network and debugging pre-made scenarios.

It is a good idea to include a short tutorial session in which revision/practice questions are answered and checked with the aid of the instructor. The tutorial questions should generally be open-ended to promote discussion and explore any weaknesses or misunderstandings the candidate(s) may have.

5 Syllabus

Introduction (marketing slide set)

Ethernet Basics

- What is Ethernet?, IEEE802.3, ISO/OSI model, TCP, UDP, IP, ARP, Ping, Ethernet frame, baud rates
- Network Addressing: MAC Address, IP Address, Subnet Mask
- Network Infrastructure
- Switches, hubs, routers, layer 3 switches, firewalls
- Switch features: Half/full duplex, auto crossover, auto negotiation, managed switches, cut through vs. store and forward
- What switch features that are required for PROFINET?
- Monitoring Ethernet traffic with switch port mirroring or a network tap
- Ethernet Wireless with IEEE 802.11
- Network topologies
- SNMP (Simple Network Management Protocol)
- LLDP (Link Layer Discovery Protocol)
- Cables and Connectors
- practical work

PROFINET IO

- Device certification requirement
- IO Controller, IO Device, IO Supervisor
- RT (Real Time) Communications
    - typical I/O cycle times
    - how it is implemented in the stack
- IRT (Isochronous Real Time) Communications
    - typical I/O cycle times and jitter
    - how it is implemented in the stack
    - IRT communication time scheduling (bandwidth reservation)
    - clock synchronization
        - IEEE 1588 V2
        - Sync Master / Sync Slave communication
        - Transparent Switches
    - Device I/O frame time scheduling (RT_CLASS_3)
    - ASIC hardware requirements
- Proxy functionality
- PROFINET in the ISO/OSI model
- IO Device Slots/subslots model
- Application Relations (AR's), Communication Relations (CR's)
- Standard channel (UDP/IP for configuration) and Real Time channel (for cyclic I/O and alarms)
- PNIO Contoller/Device Startup Sequence (connect request, parameterization, cyclic I/O, fast startup)
- Reduction ratio, send clock, frame send offset, phase
- Read and Write record services (Parameterization, diagnostics, I&M functions, etc.)
- Diagnostics (device, module, channel, network)
- Alarm types and priorities
- DCP – Discovery and Configuration Protocol

PNIO Engineering

- Importing a GSD file
- Configuring a PROFINET IO system
- Setting I/O cycle times
- Integrating a fieldbus (PROFIBUS, Devicenet, etc.) with a proxy
- Downloading PNIO device names
- practical work including troubleshooting

PNIO Ethernet Frames

- Standard Ethernet frame
- VLAN Priority Tagging
- PN Real Time Ethertype
- PN Frame ID's
- PROFINET RPC and Service PDUs
- PROFINET frames: Connect Request and Response, Write Records for parameterization, End of Parameterization, Ready for Data Exchange, Cyclic I/O frames.
- I/O data, IOPS (Provider Status), IOCS (Consumer Status)
- Cyclic I/O Watchdog Timeout
- Read and Write Record request and response frames
- Alarm Notification and Alarm Acknowledge frames

Introducing Wireshark

- How to capture Ethernet frames
- Setting up PROFINET coloring rules
- Show screen shots of startup sequence frames
- Troubleshooting typical startup problems
- Hands-on work:
    - Capture a Startup Sequence and examine the frames
    - Capture an alarm and examine the frames
    - Examine pre-recorded Wireshark files with startup problems
    - Examine pre-recorded Wireshark files with RT_CLASS_3 (IRT) frames

IRT Calculations

- Minimum Ethernet frame time
- Time for minimum Ethernet frame from the IO Controller to the most remote IO Device
- Time for all devices to receive I/O data from IO controller
- Determine how many devices can be updated in a specific time
- Maximum number of hops through switches considering jitter.

Introducing PROFINET XML-Viewer

- GSD file naming convention
- Vendor ID and Device ID in file
- Browser view and XML view
- DAP's, Modules, Parameters, Value Lists, Channel Diagnostics text, Icon Bitmap file, Module Categories, Multiple Language support
- practical work

6 Typical Practical Work

- Commissioning of the given plant with the Engineering tool of the given IO Controller, includes: importing of GSD files of IO Devices, assigning names to the devices, downloading the configuration
- Recording of the Ethernet Frames with Wireshark during start-up phase and normal operation, interpretation of the frames
- Causing errors/alarms, recording of the transferred Ethernet frames with Wireshark, interpretation of the frames
- Constitution of a faulty system by the trainer (wrong IO configuration, wrong device name, wrong cable or not 100 Mb/s Full-duplex), finding of the error by trainee and correction of the error
- Reading I&M functionality if supported by IO Controller application or Engineering tool

7 Training Equipment

The typical training equipment is given as a guide. Each PITC can decide on the configuration of the equipment so long as the syllabus for the course is covered and the learning outcomes achievable.

Example set-up:
Engineering tool, GSD Viewer, (IO Supervisor), IO Controller, 2 IO Devices, 1 monitoring switch, Wireshark, cables and connectors, stripping tool, devices from at least 2 different manufacturers shall be included.

Devices and components from any supplier can be used (connectors, cables, passive devices). Recommendation: at least 2 different suppliers should be included in the equipment.

No more than two students should share a training kit.

8 Assessment Scheme

The assessment is a combination of practical and theory examinations. Candidates must pass both components to pass the course. A candidate must score 70% in each component to pass the course.

Practical Test (Duration 1½ - 2 hours)

- Create a new configuration in the given PROFINET Engineering tool applicable to the given plant, download the configuration, and commission the plant
- Record a PROFINET IO Connect Request frame with Wireshark and determine how many communication relationships were established

Theory Test: (Duration 2 Hours)
The candidate will be examined on the following topics:

- Network general
- Network PROFINET IO
- Network Physical
- PROFINET IO basics
- PROFINET IO GSDML

For successful examination a score of 70% has to be reached.

The exam questions must be picked from a central database of questions; this database is set up and administered by PI. This task may also be delegated to a member of the TC1/WG6. Each question in the database is given a weight in points. Each PITC should select appropriate number of questions from each section to achieve the breakdown given above.

9 Text Books and References

[4.182] Popp. M.," The Rapid Way to PROFINET", published by PI and available at www.profibus.org, 11.2004

[4.132] PROFINET System Description – Application and Technology – published by PI and available at www.profibus.org
[2.352] GSDML Specification for PROFINET IO, published by PI and available at www.profibus.org
[8.062] PROFINET Planning Guideline, published by PI and available at www.profibus.org
[8.082] PROFINET Commissioning Guideline, published by PI and available at www.profibus.org

All these white Papers are published by PI and available at www.profibus.org (click on the link in the text).

1. PI White Paper Enhancing the High Performance of PROFINET
2. PI White Paper Strategic Overview: PROFIBUS + PROFINET
3. PI White Paper: PROFINET and IT
4. PI White Paper: PROFINET In Context

