PROFIBUS

Learning Outcomes (LO) of

Certified PROFIBUS Engineer
CPE

Version 0.2
August 2008

Order No: 4.712

PROFIBUS INTERNATIONAL

PROFIBUS Learning Outcomes, Order No: 4.712

Course Title: **Certified PROFIBUS Engineer**

Course Code: **CPE**

Course Duration: **3.5 Days (3 Days + 0.5 day for examination)**

Grading Type: **Normal**

Prerequisite: **- Certified PROFIBUS Installer Course**
- Industrial Automation Background

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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 Engineer
4.822 Certified PROFINET Installer

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1 Aims & Objectives

PROFIBUS is the leader of the fieldbus market and its market share is continuously growing. The objectives of this course is to provide both hands on and theoretical training program on PROFIBUS-DP. The course will provide an opportunity for the participant to acquire the required skills to design, set-up, operate, diagnose and troubleshoot DP networks.
The Course is suitable for those with no previous experience of fieldbus or digital communications networks. However, even experienced technicians can gain significantly from taking this course. The course provides an advanced stage of training for those who are involved with the design, installation, commissioning and ongoing maintenance of PROFIBUS networks.
The course aims to give an introduction to PROFIBUS system terminology, operation and characteristics. Advanced network and device testing techniques are covered, exploiting powerful bus monitor to troubleshoot running networks.
The course focuses on the PROFIBUS DP V0 features, providing deep knowledge of telegram structure, diagnosis, parameterization and configuration.

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 candidates will be able to:	**Assessment Mode**
General PROFIBUS knowledge	
Know how PROFIBUS International is organised and know how to obtain information and support.	Theory Exam
Know the master slave architecture of a PROFIBUS network. Evaluate the maximum number of slaves in a network	Theory Exam
Describe the available range of PROFIBUS addresses and know which addresses are reserved. Know how to set and check the address of a PROFIBUS device. Understand the effect of duplicate device addresses.	Theory Exam / Practical Exam
Describe the implications of using various network bit rates and understand the effects this has on network layout, performance and robustness.	Theory Exam
Appreciate the various devices that are found on PROFIBUS networks. Understand concept of network configuration.	Theory Exam
Distinguish between MC1 and MC2 functions. Exploit the SAPs to determine the right function of telegrams	Theory Exam / Practical Exam
Understand bus parameters and their effect on the bus cycle.	Theory Exam / Practical Exam
Know the retry mechanism of PROFIBUS and its implications on the network behaviour	Theory Exam

Know the start up sequence of a slave and the telegrams related to each state.	Theory Exam / Practical Exam
Signal transmission technology, wiring and shielding:	
Know the relation between baud rate and segment length. Know also the relation between baud rate and spur length	Theory Exam
Understand how repeaters, fibre-optic links and couplers can be used to segment a network.	Theory Exam
Understand where RS485 and FO transmission are applied with PROFIBUS DP.	Theory Exam
Understand the basic mechanisms of interference pickup and methods to avoid or reduce pickup on PROFIBUS cables.	Theory Exam
Understand the concept of “termination” and the importance of matching cable characteristic impedance.	Theory Exam
Know how to correctly use repeaters and active terminators to build a maintainable network.	Theory Exam / Practical Exam
Trouble shooting and Commissioning	
Know how to connect/insert a bus monitor in a network without affecting its normal behaviour.	Theory Exam / Practical Exam
Describe the expected DC voltage, waveform shape and the minimum and maximum voltage levels for RS485	Theory Exam
Know how to use tool like the oscilloscope to make measures on a running network.	Practical Exam
Know how to correctly terminate RS485 segments and recognise the many pitfalls that can lead to incorrect termination.	Theory Exam / Practical Exam
Understand the effect of segment isolation on the observed waveform when using repeaters, couplers and fibre optic segments.	Theory Exam
Given bus monitor traces and raw telegrams from a PROFIBUS DP network, identify the network faults.	Theory Exam
Use of GSD files	
Know how choose the right GSD file for a slave device.	Theory Exam / Practical Exam
Understand the main keywords of a GSD file and their effect on a the network/device	Theory Exam
Know how to select the right module for a modular slave	Practical Exam
Design techniques	
Know how to correctly create a PROFIBUS network under given constrains. Know how to use repeaters and address assignment to fulfil the design requirements	Theory Exam
Apply the rules for RS485 segment layout in terms of cable length, spur lengths.	Theory Exam

3 Instructors

The instructor(s) must have passed the Certified PROFIBUS 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 customised 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 testing 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

5.1 PROFIBUS Overview

- ☐ Advantages of networked instruments versus point to point connections. The position of fieldbus and Ethernet in the control system hierarchy.
- ☐ Market positioning of PROFIBUS. Basic characteristics and operation of PROFIBUS networks and its application areas.
- ☐ PROFIBUS Profiles overview. Overview of FMS, DP and PA.
- ☐ The PI Organisation and support: RPAs, PICCs and Test Centres. Finding the PI web site.

5.2 Bus physics & Wiring

- ☐ Basic RS485 segment layout rules, device loading, cable lengths and permitted stub line lengths.
- ☐ Special requirements for bit rates greater than 1.5Mbit/s.
- ☐ Cable specification for PROFIBUS RS485.
- ☐ Cable types for different installations (flexible cable, fixed cable, robust cable etc.)
- ☐ Causes and effects of reflections within communication systems.
- ☐ The concept of cable characteristic impedance and matching end of segment terminations. The PROFIBUS RS485 active termination box.
- ☐ Termination rules and pitfalls (multiple and hidden terminations, un-powered termination no termination on stub lines etc.)
- ☐ The concept of network and segment.
- ☐ Use of repeaters to create complex network. Basic description of repeater structure and benefits
- ☐ Overview of network components
    - Connectors (DSUB 9, M12)
    - Repeaters
    - Bus terminations
    - Active termination
    - DP/DP coupler
    - etc

5.3 Shielding, grounding and cable segregation

- The basic mechanisms of interference pickup on signal cables: electrostatic and electromagnetic coupling.
- The concept of balanced and unbalanced transmission and how these are affected by interference and earthing. Use of balanced transmission within PROFIBUS and the importance of proper screening and earthing.
- Basic rules for grounding RS485 segments.
- Cable segregation for avoidance of pickup.
- Use of trunking and cable trays.
- The earth loop problem and solutions. Potential equalisation, capacitive grounding, fibre optics.
- Special requirements for internal cabinet wiring; cable screen grounding on entry and exit, segregation, wiring devices in close proximity, problems due to excessive cable bending.

5.4 PROFIBUS Basics

- PROFIBUS and the OSI model
- Master/slave architecture of PROFIBUS. Single master and multi-master.
- Token passing in multi-master networks
- Device addressing, available and reserved addresses. Methods for setting the device address.
- Concept of bit rate (Baud rate). Standard PROFIBUS bit rates. Bit rate setting and automatic detection.
- The concept of “Network configuration tool”. Network cycle versus PLC/DCS scan cycle
- Definitions of Class 1 and Class 2 masters (MC1/MC2) and passive slave.
- Simplified start up sequence of a network
- Data-exchange timing for a slave device.
- Fail-safe feature of a slave device.
- Relation between baud rates and segment/network dimension.

5.5 PROFIBUS Details DPV0

- PROFIBUS telegrams and their structure
- Format of the transmitted characters: concepts of start/stop bit and parity
- Introduction to the Service Access Points in PROFIBUS.
- Detailed start up sequence of a slave
- Parameterization. Analysis of the parameterization telegram: how to individuate and decode each telegram field.
- Configuration (simple, special). Analysis of the configuration telegram: how to individuate and decode each telegram field.
- Diagnostics (station, module, channel). Analysis of the configuration telegram: how to individuate and decode each telegram field.
- Data exchange telegram and its relation with the configuration phase

5.6 Bus parameters & Cycle times

- ☐ Bus parameters and their impact on network performance (at least describe: Tsdr, Tidle, Tqui, Tset, Tslot)
- ☐ The retry mechanism and its effect on the cycle time. The max retry limit.
- ☐ The concept of scanning for new masters with FDL messages. The GAP update factor and the High Station Adress.
- ☐ Watchdog timer in the slave
- ☐ Calculation of bus cycle time for single master systems
- ☐ Calculation of bus cycle time for multi- master systems

5.7 Further DP functions and Master Class 2

- ☐ Introduction to the GSD files for network configuration. Description of GSD structure and analysis of GSD files for simple slave and modular slave
- ☐ States of a DP Master and the related bus activities.
- ☐ Global Control telegrams. Analysis of the Global Control telegram: how to individuate and decode each telegram field.
- ☐ Description of the SYNC/UNSYNC command and its use
- ☐ Description of the FREEZE/UNFREEZE command and its use
- ☐ Other MC2 functions
    - Set Slave Address
    - Read Inputs
    - Read Outputs
    - Get Diagnostics
- ☐ MC2 & MC1 (master to master) communication
    - Get_Master_diag
    - Start_seq
    - Download
    - Upload

5.8 Trouble Shooting tools:

- ☐ Introduction to trouble shooting tools like:
    - Handheld tools
    - Configuration tool
    - Device LEDs
    - Bus monitor
    - PLC Program
    - Diagnostics repeater.

5.9 DP Extensions

- ☐ Extended parameterisation, Configuration, and diagnostics.
- ☐ Additional Acyclic services for:
    - MC1 (Read/Write Data Set, Alarms…)
    - MC2 (Read/Write Data set, Initiate/Abort…)

6 Typical Practical Work

6.1 Network Set-up

- ☐ Installation using pre-made cables, correct use of terminations
- ☐ Use of network configuration tool to setup sample networks
- ☐ Use of GSD files
- ☐ Configuration and test of bus timing of sample neworks
- ☐ Data Exchange and Read/Write data from slaves
- ☐ Effect of watchdog timer on data exchange
- ☐ Group assignment during network setup
- ☐ Scan network for attached devices.
- ☐ Decode PROFIBUS Telegrams

6.2 Network debug with bus monitor

- ☐ Description & use of bus monitor to capture:
  - Parameterisation
  - Configuration
  - Diagnostics
  - Data exchange
  - Global control
  - FDL status
  - Token telegrams
- ☐ Use of the oscilloscope to check signal levels & capture telegrams
- ☐ Set-up and use MC2 functions
- ☐ Set slave addresses to new values. Check the slave addresses.

7 Training Equipment

The following description of training equipment represents a minimum requirement and is included as a guide only. Each PITC (PROFIBUS International Training Centre) is free to decide on the precise type of equipment and its configuration. The practical setup must be suitable for the teaching and practice exercises and for the practical test.

Example set-up:

A typical training kit should meet the following minimum requirements:

- It should have at least three slave devices with standard connectors. Ideally one slave should be a modular device and one compact. If possible the slaves should incorporate two different methods of setting the address (i.e. one with rotary switches and one with binary or DIP switches).
- Some kind of I/O simulator must be provided.
- At least one class 1 master or master simulator should be included to exercise the network.
- The master and the slaves should be mounted together with a suitable power supply. Note that manufacturer's electrical safety instructions should apply to the power supply wiring.

- Sufficient pre-made cable with connectors should be provided to allow the master and the slaves to be wired into a single segment.
- No more than two candidates should share a training kit.
- Each pair of candidates will require a bus monitor tool.
- A set of pre-programmed network configurations (scenarios) of network with fault (e.g. double addresses, wrong ID number, etc) should be available to be downloaded in the master.

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.

8 Assessment Scheme

The assessment is a combination of practical and theory examinations. Candidates must pass both components to pass the course. A score of 70% is required to pass each component. All testing is “open book”, that is the candidate can use the course notes and other reference material freely during the test.

Practical Test (Duration 2 hours)

The practical test should be carried out using the same training equipment the candidate use during the training. The practical test should be organized as follow:

Build and test a PROFIBUS network. Set addresses, choose the right GSD file, measure bus parameters	50%
Diagnose the problems of a not working network using the available tools	20%
Troubleshoot to recover the system to normal working condition	30%

During the practical test the instructor/examiner should check the correctness f each section when complete.)

Theory Test: (Duration 2 Hours)

The exam questions are to be picked from a central database of questions. This database is set up and administered by PI. Each question in the database is given a percentage weight. Each PITC should select appropriate number of questions from each section to achieve the approximate breakdown given bellow.

General PROFIBUS knowledge:	35%
Signal transmission technology, wiring and shielding:	25%
Trouble shooting and Commissioning	15%
Use of GSD files	5%
Design techniques	20%

9 Text Books and references

1. PI PROFIBUS Installation Guide for Cabling & Assembly, Order No: 8.022

2. Popp.M.,” The new rapid way to PROFIBUS DP”, PNO, No 4.072, 2003
3. Mitchell, R.W.,”PROFIBUS, A pocket guide,ISA, 2004
4. Weigmann, J.,” Decentralisation with PROFIBUS-DP: architecture and fundamentals, Siemens, 2000.

